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THE STEREOSCOPE AND ITS APPLICATIONS.

BY PROF. CHAS. F. HIMES, Ph.D.

(*Concluded from vol. cxxiii, page 408.*)

[*A Lecture delivered before the* FRANKLIN INSTITUTE, *January 14, 1887.*]

A very simple form of instrument, and one of great convenience, which leaves the hands perfectly free, and which anyone can adopt to his own interocular distance, is that of spectacles, with stereoscopic semi-lenses; or, as I have found equally effective, ordinary spectacles of about six inches focus, simply widened by inserting a piece in the bridge, so that the eyes may look through the margins of the lenses instead of through the centres. But it may be asked if the instrument does so much, what becomes of the criterion of muscular effort in the movement of the axes? We will see that there is still residual work of this kind to be accomplished, because of the impossibility of the exact superposition of dissimilar pictures. Let us see, therefore, in what this dissimilarity consists, and how it may be best stated for our purposes. Let us take as a very simple subject, the screen of vertical lines as our background

for convenience of reference, and the rod with an arrow of black card-board several feet in front of it.

Upon looking at it first with one eye open and then with the other eye open, while the head is kept in a fixed position, it will be noticed that the projection of the arrow referred to the same line on the screen, will be further to the left when looked at by the right eye than when looked at by the left eye. Or we can say that in right-eye pictures objects in the foreground are further to left of the same object in the background compared with the left-eye picture. So in the diagram (*Fig. 9*) the upper pair of diagrams would represent right- and left-eye drawings of a concave frustum of a cone, because the centre of the smaller base in one case is further to the right, and in the other further to the left compared with the centres of the larger bases, while the lower pair of diagrams, for similar reasons, represents a convex frustum. This rule applies, of course, to the most complicated subject, and would enable any one to assort unmounted photographic stereographs, as has often been my own practice. But it will answer our purpose better to describe the completed stereograph,—the pair of pictures mounted properly upon a card. In this case, we see at once that similar points in the foreground will be nearer together than similar points in the background. Thus, we might say that in the stereoscopic diagram of the convex frustum of the cone the centres of the smaller circles are nearer together than those of the larger circles. Thus, as we measure with a pair of compasses, the distances between the similar points of a more complicated stereograph, passing from objects in the immediate foreground, there will be a gradual slight, but very perceptible, increase in the distance.

Now, to return to our simple diagram (*Fig. 2*), and regard both sides of it. Two of the squares will be seen to be nearer together, and in the stereoscope binocular combination will take place, and that difference assert itself by invariable, uncontrollable, persistent location of that square in front of the other. This rule, which serves to test the correctness of the mounting of the pictures of a stereograph, serves just as well to answer a very natural query that arises here, as to the effect of incorrect mounting,—of transposition of the pictures, thus presenting the left eye the right-eye picture, and at the same time the right eye the left-eye picture. This

would simply reverse the order of the distances between similar points. Objects in the foreground would now be further apart than objects in the background. The binocular combination of these by means of the stereoscope, by its inexorable method, would reverse the natural distances of the objects from the eye. Objects in the background would be brought to the front, and those in the foreground be caused to recede into the distance. Forms would be inverted. Elevations would be converted into depressions, and depressions into elevations, relief into intaglio. This false effect, called pseudoscopic effect, to distinguish it from the ordinary stereoscopic effect, is one of the most interesting facts, and one most strongly corroborative of the theory of the stereoscope. It also opens up a fruitful field for experiment and investigation, sometimes disappointing us, but oftener affording remarkable surprises in spite of all ground for anticipation. In *Fig. 9* you will readily notice that the transposition of the diagrams of either pair will produce the other, with the reversed stereoscopic effect. So the most complicated photographic stereographs, with every variety of object, and all their wealth of detail—landscapes, interiors, statuary, apparatus—if cut apart and transposed, should manifest a similar effect. The ordinary stereographs in the market answer very well for experiments. But all will not be found to respond to our statement. In many cases, especially when persons have not been apprised of the change, and are unaccustomed to critical use of the instrument, the stereoscopic effect will apparently persist, not as strikingly, perhaps, there may be an expression of dissatisfaction on the part of the observer in comparison with some other stereographs, accompanied, it may be, with the statement, that it appears better with one eye than with both, but the trees in front of the cottage refuse to recede behind it, the portico will not move to the rear, and the sloping lawn in front not slope to the rear, at an opposite angle, as they all should. Neither will a face appear as a mask. This results simply from the struggle between what is usual and natural and anticipated and what is unusual or unnatural, and often even impossible; between the single binocular criterion and the cumulative effect of all the monocular criteria of distance and form. Thus, that the trees should recede beyond the cottage, implies not only a violation of ordinary perspective, but an unnatural appearance of transparency in the cottage. But often after prolonged examination, the

absolute character of the binocular criterion, its entire independence of the conditions of ordinary perspective, manifests itself, first in a recognized persistence in the disposition of some object in the background to start to the front, as binocular perspective overbears all ordinary perspective.

At first it may be such objects as do least violence to our preconceived notions of position, and finally all will come into the most unnatural positions as demanded. But this control over us of what is usual in appearance, which we found applied to the objects themselves, when viewed with one eye, as in the mould which I exhibited, which appeared to be a relief, applies, in many cases, even to the stereographs of the objects. The stereograph of the mould, even to experts, does not, at first, manifest its true character, and, of course, it would be expecting too much that the transposed stereograph of the medallion should appear as a mould. But frequently when difficulty has been experienced by individuals in obtaining pseudoscopic effect, I have succeeded in causing it to appear at once by placing the familiar object in an unusual position. By simply turning the pseudograph, as we may call it, upside down in the stereoscope, its true character will often appear. Thus the stereograph of the mould upside down occasions no difficulty, and then, generally, when placed in its proper position, it retains its character as a mould. So, too, the mould photographed in a horizontal position I find is more likely to maintain its character in the stereoscope. Again, by taking advantage of accidental features, for example, the tacks by which it is fixed to the support or the knot on a cord, these readily assume their proper positions, and, insignificant as they are, drag the whole picture into proper relief. Nothing exhibits more clearly, than such facts as these, the effect of the most minute conditions in stereoscopic vision. In the photograph upon the screen, a combination has been made upon a table of objects of wood, metal, and glass, some with peculiar lustre, of familiar and unfamiliar forms and sizes, and without marked background. It forms a beautiful stereograph. But, when mounted pseudoscopically, at first it is very unsatisfactory, persons sometimes stop and wipe the glasses of the stereoscope, but finally, as a rule, the objects arrange themselves in inverse order, suspended in mid-air, on a plane with the reversed slope of the table. The effect is magical. When great difficulty is experienced in obtaining it, simple inversion of the pseudograph will produce it, and it

will be retained after it has been properly placed. The photograph of the old jelly mould on the screen is an excellent subject that yields its proper effect at once. It is a suggestion taken from Dr. Carpenter. There is little familiar about it.

Now, the differences between the binocular pictures, minute as they must necessarily be, would entirely escape representation in any ordinary drawing, and in a subject of any complexity, even with the greatest care could not be rendered, might even be reversed in character. The infinitesimal character of the differences between the binocular pictures, which the eyes can take hold of and translate into distance and form, can hardly be appreciated from mere statement. If a slip, about 2¾ x 2¾ inches, is printed from ordinary type, and the type are then distributed and reset, as nearly as possible in the same way, an impression from the latter combined in the stereoscope with one from the former, will manifest differences in the projection of some letters in front of the plane of the paper, and the recession of others behind it, or even of words inclined at different angles to the plane of the paper—effects due to varying distances between the similar letters. It has been proposed to test bank notes in this way. If similar halves from the same plate are combined in the stereoscope, they will remain flat, whilst if halves from different plates are combined, the minutest differences will manifest themselves, as in the printed slips alluded to. So the celebrated Chimenti pictures in the Museum at Lille, which Sir David Brewster regarded as stereoscopic mates, on close examination only exhibit such differences as might be expected between any original and its copy, as they give mixed pseudoscopic and stereoscopic effect.

But just at this point, photography comes to our aid, rendering, with mathematical accuracy, minutest differences. All that would be necessary, would be to take two pictures from points of view about three inches apart, either with the same camera in succession, or with two cameras simultaneously; or, with what is practically the same, the so-called stereoscopic camera, in which case, the two pictures are on halves of the same plate of glass. One advantage of the double camera is, that moving objects are included in its range. But when the negatives are on the same piece of glass, the paper prints made from them must be cut apart, and transposed in mounting for the stereoscope. This has puzzled

many, for is not the right-eye picture on the right half of the glass, and the left-eye on the left half? Even Sir David Brewster* seems to reason somewhat in this way in his description of what he calls a camera stereoscope, which he recommends very highly. He says, that by combining the two pictures on the ground glass of a binocular camera, by means of a lenticular stereoscope attached to the back of it, groups of figures, and so forth, may be seen in relief—upside down, to be sure, but in relief. It is not easy to test this statement with the ordinary stereoscopic camera, because the lenses are more than the interocular distance apart, and the similar points of the ground glass pictures are too far apart, but by cutting a strip out of the centre of the negative taken with one of these cameras, as I have done, and thus bringing the similar points within two and three-fourth inches of each other, and then supporting the halves on a piece of plain glass, just as they present themselves to the eye on the ground glass, and introducing them into the stereoscope, the same effect should be produced. It will be found to be pseudoscopic. If the subject has been carefully selected, unmistakably so; if a landscape, or a portrait, the difficulty before alluded to, in obtaining it, will be experienced. As this fact has a bearing on other interesting applications of the stereoscopic principle, we may take more time to make it apparent. Let us test it by our simple rule, that similar points of the pictures nearer together will appear nearer the observer. Any change in the position of the pictures that does not affect this condition will not affect their binocular character. Now, what is the character of the picture on the ground glass. First, let us note what presentations of a transparent picture can be made. On the screen will be recognized a negative of our screen of vertical lines and arrow. The letters have been introduced to indicate changes. First then we have the normal position, next simply turned upside down, next in an upright position, but as if seen from the other side, or looking upon the face of type—say type-inverted, and lastly, both upside down and type-inverted. Now, the image of an object thrown by a lens appears upside down and type-inverted to an observer upon the same side of the screen as the lens, or as it would appear to you if the lantern were projecting images from objects in their natural position, *Fig.*

* *The Stereoscope*, p. 126.

6, a, but if these same images upon the screen were looked at from the other side of the screen, they would still be upside down, but the type-inversion would be corrected; they would only be upside down, like a negative, upside down and with the film side from you. which, by simply turning right side up, becomes normal, *Fig. 6, b*, Now, the two pictures thrown upon the ground glass of the binocular camera have the same character; seen from behind on the ground glass, they are simply upside down. (By means of transparent screens carrying enlarged right- and left-eye pictures, the lecturer illustrated this point fully.) Thus we see that by taking two stereoscopic pictures, which are properly placed, and turning

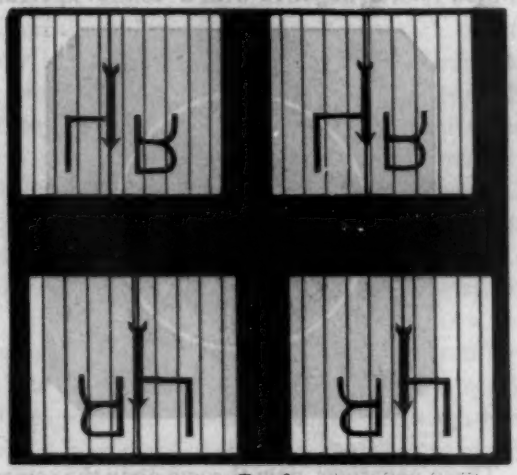

FIG. 6.

each for itself upside down, we can change the relation between the distances of similar points in the pictures; those that were nearer together before will now be further apart—the combination will be pseudoscopic. If it is a glass stereograph, and we fasten the pictures in their new positions, no turning of the whole combination, no mode of looking at it from front or rear, can change this condition—it is pseudoscopic and will remain so until each picture is inverted for itself, or until they are separated and transposed, which would bring the same edges of the halves together as separate inversion would. Thus the pictures on the ground glass of the stereoscopic camera are simply upside down, *Fig. 6, b;* if each could be turned right side up for itself the combination would be

stereoscopic; unless that is done, the combination must be pseudoscopic. The images upon the ground glass can not be inverted, but a perfectly equivalent experiment can readily be made with a glass negative. But let us notice the effect of the width of the lens upon the picture produced by it. Each part of the lens contributes to the picture. Now, I placed in front of an ordinary one-fourth size portrait lens, about one and one-half inches in diameter a stop with an aperture three-sixteenths of an inch in diameter at *a* (*Fig. 7*), with its centre three-eighths of an inch from the centre of the stop and took a negative; then took a negative with a stop with an aperture at *a*, of same size and at the same distance from the centre, and then took a negative with a central aperture *c*, of the

FIG. 7.

same size. These negatives, now thrown upon the screen, manifest unmistakably the same differences that would be expected in pictures taken by lenses separated the same distance from each other. Prints from any two of them combined in the stereoscope give an effect as decided as any ordinary stereograph. Even the combination of the picture by the central aperture with one by a lateral aperture is very decided. It is plain, then, that when the full aperture of the lens is used, the resulting picture must be a fusion of many dissimilar pictures, and, in so far, must be wanting in precision. This will be true, of course, to the greatest extent of objects in the immediate foreground. Want of sharpness in cases of near objects is doubtless often attributed to other optical conditions, especially as a diaphragm in front of the lens is a remedy

for this unsuspected cause of defect, as well as for many others. Sir David Brewster was so impressed with this defect of photographic lenses, that he suggested a simple pin-hole camera as the ideal camera, when photographic processes should have become sensitive enough; and as we appear to have reached unlimited photographic sensitiveness, Capt. Colston,* of Paris, has recently given us an illustrated brochure upon the pin-hole camera. Experiments with such a camera some years ago, with wet plates, developed defects that deprive it of an ideal character. But to return to the stereographs by the lens. The subject was selected to bring out this fact. The object, pencils, pens, etc., ranged in distance from the camera only from twenty to twenty-nine inches, and their maximum lateral distance from each other was nine inches. Now, what is true of the pictures by different parts of one-fourth size lens, must be equally true of the pictures by different portions of any lens, however small, even of a microscopic objective, if the object is correspondingly small. If, therefore, a photo-micrograph be taken with one-half of an objective, and then one with the other half of the objective, these two combined in the stereoscope should give an appearance of relief that the microscope itself could not give, free from errors of interpretation, as to distance and form. And so they will. I have here a stereo-micrograph of sun-stone, in which the crystals are located by the stereoscope, and the section shows depth, and all the qualities of the ordinary stereograph. It was taken many years ago by Prof. O. N. Rood, now of Columbia College, and the method published,† and it is a matter of surprise that in these days of photo-micrography, no one has cultivated this branch, or indeed that micro-stereographs of many objects are not in the market. I would just say that the method suggested, although giving results as stated, was abandoned by Prof. Rood for another, principally on account of difficulties in illumination. But we are not restricted to photo-micrographs in the application of the stereoscopic principle. As might have been anticipated, soon after the realization of the great superiority of vision with two eyes over monocular vision, attempts were made to apply the principle in microscopic vision. The difference between

* *La Photographie sous Objectif.* Paris, 1887.

† *American Journal of Science*, vol. xxxii, p. 192. 1861.

the views of an object by the different halves of the objective was recognized, and the possibility suggested of presenting one to one eye and the other to the other eye, and thus obtaining microscopic vision in relief. Prof. Riddell, of New Orleans, seems first to have devised a binocular microscope in 1851; but in his first instrument the right eye looked through the right half of the lens, and the result was not stereoscopic, but pseudoscopic. In describing the appearance in it he likens a metal spherule to a glass ball silvered on the underside, and a crystal of galena to an empty box.*

You might have inferred as much from the full discussion we have had, with this application in view, of the so-called camera stereoscope of Sir David Brewster. The pictures through the halves of the lens, as they are inverted, are similar in binocular

FIG. 8.

character to those of the ground glass of the stereoscopic camera, and to produce stereoscopic effect, it is necessary that they should be transposed; that the right eye should look through the left half of lens, and the left eye through the right half. Many optical contrivances have been devised to meet this requirement, but that of Mr. Wenham has done so much by its extreme simplicity and cheapness, as well as effectiveness, to render the binocular microscope a possibility for all, and that, too, without loss of its monocular character, that it will serve best for illustration. In the diagram (*Fig. 8.*) it will be noticed, that the ray to the right eye passes directly through the left half of the lens, whilst the ray through the right half of the lens is deviated across the original path into the

* *American Journal of Science*, vol. xv. 1853.

left eye, by means of a peculiar prism placed above the objective. In the larger diagram of the prism the ray may be followed, entering perpendicular to the lower surface, then totally reflected and again totally reflected, and emerging finally from the prism at right angles to its surface, consequently without refraction, in such direction as to enter the left-eye tube of the binocular body.

By sliding this prism out, the instrument can at once be converted into a monocular, and again be as readily converted into a binocular, thus affording apportunity for comparison of the two effects. Two *à priori* objections prove in practice groundless. First, the image formed by rays passing through the prism, as they traverse a longer path, will be larger, and, by reason of reflections and imperfections of the glass, less distinct than the other. But it can easily be demonstrated by the stereoscope that slight differences in size can be overcome by the eyes, and that even a faint or imperfect picture can contribute a great deal when combined stereoscopically with a perfect one. The advantages of a binocular microscope, in cases where applicable, cannot be overestimated. The comfort in the conjoint use of both eyes, especially to those unaccustomed to the use of the microscope, is great; even a non-stereoscopic binocular, in which portions of light from the whole lens pass into each eye, adds much to comfort in use. But this question as to whether there is any advantage in a binocular microscope is so often asked, that I will simply give the opinion of Dr. Carpenter upon the point. He says, that in no way could he as certainly or as vividly image the form to himself, or be as conscious of saving fatigue. That this is not attributable merely, perhaps not so much to the conjoint use of the two eyes, as to absence of mental effort required for the interpretation of the microscopic pictures, when the solid form has to be ideally constructed from it, chiefly by means of information obtained by focal adjustment, instead of being presented directly to the mind's eye. Not all writers on this subject are equally clear. Hogg says, that the great disadvantages of the earlier forms of binocular microscopes was, that to most persons the view given was pseudoscopic, when in the nature of the case, as we have seen as far as there was any effect, it should have been pseudoscopic to every one; some might have overlooked it, or been controlled by other conditions, but in no case could true stereoscopic effect be produced. Even so

high an authority as Helmholtz* accompanies the statement, that the stereoscopic effect is very surprising and facilitates wonderfully the observation of complicated forms, with another, that it occurs by reason of entirely different conditions than in other stereoscopic instruments. That we have here no pictures of an object taken from different points of view, for one objective of the microscope furnishes both pictures for both eyes, and only half of the light is assigned to one eye, and the other half to the other eye. His elaborate explanation of the effect involves the formation of confusion circles by points out of focus. Now, whilst vision with the binocular microscope is abnormal, and modified by many conditions, when we recall the photographic pictures furnished by different halves of the one-fourth size photographic lens, and their perfect stereoscopic character, we cannot exclude the same condition present in the use of the binocular microscope, from the principal share in the production of the effect.

But we have employed the term convergence of the optic axis in such a way, that the impression may have been created that such convergence is necessary for stereoscopic effect. This was, indeed, almost a controlling view with the early investigators of the subject. Now, whilst there is necessarily always convergence of the axes, to some degree, in normal vision, I was convinced, many years ago, upon investigation, of the non-essential or secondary character of this condition in production of stereoscopic effect,† and the subject has more recently been independently, most exhaustively discussed by Prof. LeConte Stevens.‡

It may be regarded as accepted, that convergence is not necessary. Experiments may easily be made by anyone upon that interesting point by means of ordinary stereographs. By looking at a distant object, not too intently, and introducing before the eyes, at about the limit of distinct vision, an ordinary stereograph, after some practice, the habit of accommodation and convergence will be overcome. Four pictures may at first appear, but gradually the interior ones will approach each other, and finally coalesce, with

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* *Physiologische Optik*, p. 682.

† *American Journal of Photography*, September 1, 1862. *Proceedings of New York Academy of Sciences*, February 13, 1882.

‡ *American Journal of Science*, vol. xxii, p. 358. 1881.

resulting stereoscopic effect. In this case, controlled by the convergency theory, it was regarded as an essential condition of success by Brewster, Rogers, LeConte, Tyndall, and others, that the distance between similar points of the two pictures should not exceed the interocular distance, say two and three-fourths inches. If by practice, however, anyone should acquire facility in thus combining the pictures of the ordinary stereograph, it will be found that, by cutting them apart, and gradually sliding the halves further apart, combination can be effected when the distance exceeds three inches, or even four inches in my own case, and with complete stereoscopic effect, although, in such cases, the axes must be divergent. Still, in this case, there remains the necessity for movement of the optic axes, as they pass from points nearer together to other similar points further apart, a movement associated with normal perception of distance and form. But this perception of stereoscopic effect, whilst the optic axes are divergent, is far more common than might be supposed. In many, perhaps most, cases, in using a stereoscope there is this divergence. In many of the stereographs in the market, the distance between similar points greatly exceeds the average interocular distance, and the prisms do not produce superposition. Prof. LeConte Stevens, by comparing the foreground interval of a large number of stereographs with the deviating power of thirty different pairs of lenticular prisms, employed in the ordinary stereoscope, determined, that, for the average interocular distance, axial divergence is frequent in the use of the stereoscope.* Just at this point, we must admit that, whilst play of the optic axes is important in our study of the form of objects, there are facts that indicate that binocular perception of distance may take place, when such movement cannot accompany it. Prof. Dove first tested this, by illuminating the stereograph by an electric spark, an experiment since repeated by many, with production of unmistakable stereoscopic effect. So also an object illuminated by a flash of lightning exhibits relief. We cannot conceive of movement of the optic axes occurring in such brief intervals. The position of the pictures on the retinæ must therefore give us a criterion, not the sole one, but an important one. The theory of corresponding retinal points seems to meet the case. Stated briefly, the internal

* *American Journal of Science*, vol. xxii, p. 444.

or nasal half of one retina corresponds to the external or temporal half of the other retina. Points are seen single when their images fall on corresponding points, the images of points nearer or more remote will not then fall upon corresponding points, and they will be seen double, although we may not be conscious of the fact, and most persons may have difficulty in verifying the statement. It is this doubling of images of points nearer or more remote than those observed, and the difference in character between those nearer and more remote, that accompanies all normal vision, that unconsciously aids, at least, in our perception of distance.

Now, a few hasty suggestions as to some other applications of the stereoscope. When first introduced, its range of application seemed very restricted; even when it was widened in the number and character of its subjects by photography, it seemed restricted to objects of ordinary unaided vision. We have seen how not only the principle was soon made directly applicable to the microscope, but magnified stereographs were demonstrated possibilities. Application to extra-terrestrial objects was not anticipated. But about the same time, Rutherford and De La Rue discovered that they had stereographs of the moon. I do not know that they intentionally took the photographs with this in view. They had not taken their photographs from points far enough apart to give binocular parallax. But, if I wished to obtain a stereograph of a bust, I could either move my camera three inches to the right or to the left, or what would produce the same effect, rotate the bust on a vertical axis through a small angle, so as to bring a little more of one side into view, and take a picture. This plan, by tilting the stage of the microscope for stereographs of minute objects has already been alluded to. Now, it is true, as a general statement, that the moon always presents the same side to our view by reason of the identity of the time of its rotation on its axis and of revolution in its orbit. But it is not rigidly correct. The rate of motion varies slightly in different portions of the orbit, causing so-called libration in longitude, by reason of which a little more of one side is exposed to our view. The moon turns around just enough to afford us stereoscopic photographs at these times, which give the most surprising, in fact exaggerated, effect. Wonderful as these are, I was unable to obtain in the market those by Rutherford at all, although advertised for sale, but found some by De La

Rue. They manifest not only the form of the moon, but exhibit almost a pitted appearance, mountain ranges and solitary peaks stand out in bold relief. So, too, De La Rue has obtained stereographs of the sun. Between these two wide limits, the microscopic and the telescopic, lie all varieties of subjects and numberless questions, which the stereoscope can aid in investigating. The so-called "Phenomenon of the Horizontal Moon" has been discussed since the days of Ptolemy. The illusion of size depends on the illusion of distance. Sir David Brewster and Prof. Reute devised stereoscopic illustrations of this connection. That of Prof. Reute, on the screen, *Fig. 9*, will be recognized as diagrams of convex and concave conical frusta, the smaller circles in each case being of the same size, but in the stereoscope, as they are made to assume positions of bases of the frusta, the one more remote appears larger.

From several diagrams of my own on this point, I select one of some theoretical interest. In it a single small circle is represented in the right hand diagram by two equal circles at different distances (*Fig. 10*). Impressed with the necessary rapidity of movement of the optic axes in ordinary vision, my expectation was that the alternate combination of this circle, in succession, with the equal circles of the other diagram, would be so rapid, that the results could be compared, and the same circle be made to appear larger and smaller in succession. To my surprise, both frusta, the convex and concave, presented themselves at the same time, the same circle seemed to occupy two places at the same time, and with apparent size corresponding to the distance. The natural explanation was that it was an illustration of the rapidity of the movement of the optic axes, and our unconsciousness of it. But unfortunately for this view, Prof. Le Conte Stevens* has called attention to the fact, since verified by myself, that it manifests the same character when illuminated by an electric spark. Again, there are phenomena which we cannot locate in space by direct observation, for want of time, and a single photograph assists us but little in their study. The photograph of a moving object, as a ball, only gives us the projection of its path, a stereograph would locate its path in space for us. To vary the application, the photo-

* *American Journal of Science*, vol. xxvi, Oct., 1882.

graph of the electric sparks upon the screen (*Fig. 11*) exhibits a confused mass of interlacing lines. But by combining this with the stereoscopic mate, taken at the same time, this tangle of lines assumes form as the path of each spark locates itself in space. Application of this method to the photographic study of the discharges of atmospheric electricity might add to the value of such photographs. On the other hand, in the study of the forms of clouds, simultaneous photographs of them, from points widely separated, might give invaluable information. But there are ordinary subjects which photographs with all their accuracy are utterly inadequate to render, of which they give us limited and perhaps illusory information. Impressed with this fact, a few years ago, when about to make a photographic study of the glacier system around the Matterhorn, I decided unhesitatingly upon a

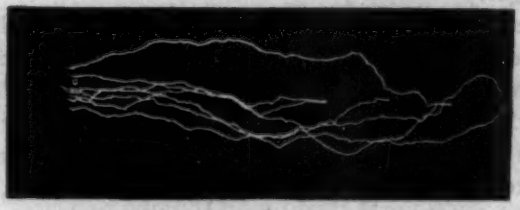


FIG. 11.

stereoscopic outfit in spite of the extreme desirability of reducing impedimenta, where mule and man transportation alone were available. A few of the finest of these, as lantern-slides upon the screen, are almost meaningless; no explanatory statements can give them full value; even these with the bold peaks and their cloud banners only reveal their exquisite beauty and wealth of detail, as any one may see, in the stereographs. But photography is not only not always essential, but not available in some most interesting investigations. Besides outline drawings and diagrams of all kinds, what has not yet been fabricated, can be drawn, the camera can be anticipated; ideal apparatus, forms suggestive or tentative, can be rendered stereoscopic, and representations of phenomena almost a substitute for the reality can be produced. A simple little piece of apparatus, devised by Prof. Rood,* renders this extremely easy.

* *American Journal of Science*, vol. xxxi, p. 71.

One of the most practical applications is in crystallographic representations. The relations of the several forms of crystals so expensively exhibited by hollow glass models with threads for axes, can be as completely illustrated by the most inexpensive stereographic drawings of every variety. Sets of stereographs of crystal forms are in the market, and books of instruction in drawing.* But there is still another quality besides form. In the diagram on the screen (*Fig. 12*), devised to investigate comparative brilliancy of objects seen by one and by both eyes, any one, upon observing it in the stereoscope, will be surprised by the appearance of lustre on the arms, where black and white are combined. The stereoscope has been employed by Prof. Dove to investigate the theory of lustre. Applying this fact to crystal models, as in diagram (*Fig. 13*), we get the additional complete reproduction of lustre, almost as of polished

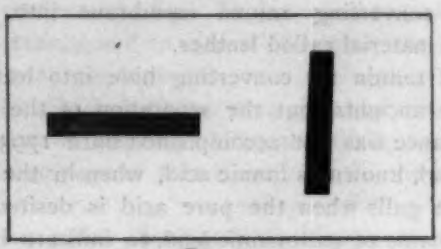


FIG. 12.

glass, as well as of form of the crystals. But we must stop, we have already far exceeded the time proposed to ourselves at the outset, and we will be glad if we have in any way contributed to a reinstatement in favor of a little instrument, which has within itself so many possibilities of instruction and pleasure.

* *Die Elemente der Krystallographie mit Stereoskopischer Darstellung der Krystallformen.*—J. Martius-Matzdorff, Braunschweig. 1871.

TANNIN: ITS PRESENT AND FUTURE SOURCES.

By PROF. HENRY TRIMBLE, of Philadelphia.

[*A Lecture delivered at the* FRANKLIN INSTITUTE, *February 14, 1887.*]

PROF. TRIMBLE was introduced by PROF. PERSIFOR FRAZER, and spoke as follows:

Tannin is a colorless, shining, amorphous, astringent body found in many plants.

It varies according to the source from which it is obtained, but all varieties appear to have the common property of forming a dark blue, or dark green color with ferric salts, giving precipitates with gelatin, and converting animal membrane into insoluble and imputrescible material called leather.

The use of tannin for converting hide into leather was well known to the ancients, but the separation of the principle as a distinct substance was not accomplished until 1793, by Deyeux. This compound, known as tannic acid, when in the pure state, is prepared from galls when the pure acid is desired; this source giving it the name of gallotannic acid, to indicate its origin, and at the same time distinguish it from numerous other tannins from other sources. This gallotannic acid has been fairly well studied, and the opinions of chemists regarding it are much more in harmony than they are in reference to the numerous compounds under the general name of tannin. We will first consider the present sources of tannin which yield us the pure acid.

Galls are the most valuable and important of all tannin materials.

The oldest and best known variety being the oak gall, which results from the sting of an insect called *cynips* in the tender bark of the young shoots of *Quercus lusitanica*, variety *infectoria*, a small shrub three to four feet in height, indigenous to the eastern part of the Mediterranean basin.

The puncture causes the juices of the plant to collect around the eggs; and the resulting galls should be collected before the insect matures sufficiently to pierce the coating and escape, for after that time the amount of tannin is very much lessened. Galls at this

stage of maturity are nearly globular, about three fourths of an inch in diameter, and of a blackish gray color. Those of a white color have been collected after the insect has escaped, and are consequently of inferior quality. The best galls come only from warm countries, those found in this country only yielding thirty to forty per cent. of tannin, while good Aleppo galls (the best commercial variety) yield from sixty to eighty per cent. tannin.

The *Chinese* variety of galls, found on the leaves of *Rhus semialata* were not a regular article of commerce until 1844.

They are very light, hollow, distorted by numerous protuberances, and completely covered by a thick velvety gray down. These galls are much used for the preparation of tannin, of which they yield from seventy to eighty per cent.

Tamarisk galls are obtained from *Tamarix orientalis*, growing in India and northern Africa. They are said to yield fifty per cent. of the purest tannin, and to impart to leather the best color and texture of any tanning material.

Barks.—Much attention has been given by our Government to the development of tannin-yielding materials, by carefully determining the percentage of this constituent in the most promising plants.

Mr. Sargent, in his *Report on the Forests of North America*, says: "The amount of tannin contained in the bark of various trees of the United States has been determined. These determinations give the percentage of tannin; they do not indicate the real value of the bark of the species for tanning, which can only be determined by actual experiment made on a large scale, other properties in the bark, beside the percentage of tannin, affecting the value of the leather prepared with it. These determinations must therefore be regarded as approximations, which will serve in some cases to indicate species not now in general use for this purpose, which may be looked to as possible sources of tannin supply."

Quercus tinctoria, or quercitron oak, is largely used in tanning, giving a reddish fawn-colored leather, and depositing a fine bloom. It contains 5·90 per cent. of tannin and yields no gallic acid. The tree flourishes in the Northern and Middle States.

Quercus prinus, chestnut oak, yields a bark rich in tannin to the extent of 6·25 per cent., and is largely used in preference to all other white oaks in the Northern States.

Quercus falcata, Spanish or red oak, gives 8·59 per cent. tannin, and grows in the eastern United States from New York south to Florida.

Quercus densiflora, tan-bark oak, grows west of the Rocky Mountains, and yields a bark containing 16·46 per cent. of tannin, which fact has made it the most popular of all tanning materials on the Pacific Coast.

In Europe, the bark of the *Quercus robur* and *pedunculata*, which grow there, are used more than all other tanning agents, but in this country there is a bark which, on account of its abundance, exceeds all others in importance in the tanning industry, namely, the *Tsuga canadensis* or *Abies canadensis*, popularly known as hemlock bark. Varieties of this tree grow abundantly in the northern United States and Canada, and the bark yields, according to the variety and locality, from 13·11 to 15·72 per cent. of tannin. So great is the value of this material, that not only is it used in enormous quantities in this country, but it is largely exported. In order to reduce the cost of transportation and at the same time furnish a more available form of this bark, it is exhausted with water and evaporated to a thick or solid extract. This is accomplished by heating in closed copper boilers the ground or chipped bark with successive portions of water until exhausted, running the resulting liquid into a large copper vacuum pan and evaporating in vacuo to the desired consistence when it is run while warm into barrels or boxes for shipment.

The annual production is not far from 15,000 tons. This extract, containing from twenty to twenty-five per cent. of tannin, is one of the cheapest sources of this important material, and the use of it is undoubtedly on the increase; not only for tanning, but very largely also for dyeing purposes, where it forms an important adjunct to many of the more expensive extracts. It is well known that oak-tanned leather is superior in texture and color to that tanned with hemlock, nevertheless, the demand for the latter steadily increases, both here and abroad.

According to the last census report, the annual production of hemlock was 1,101,526 tons, and of oak bark, 353,245 tons. So great is the consumption, that the apparently inexhaustible forests of this wood are rapidly and surely disappearing; not alone on account of the bark, but also on account of the wood, although in

many places the trees are felled, stripped of their bark, and allowed to rot. In Warren County, Pa., 5,000 acres were cut in 1880 for the bark.

Picea Engelmanni, white spruce, on account of the large amount of tannin in the bark—20·56 per cent.—has been employed for tanning in Utah. The barks of some other species of spruce are likewise very astringent.

Castanea vesca, chestnut; both bark and wood are made into an extract. Such an extract is also largely made in France, and some of it occasionally finds its way to this country. A sample which came into my possession, said to represent a large lot, was heavily adulterated with molasses, which goes to show that it is the determination of the cultivators of the beet root to find an outlet for their products. Chestnut extract is largely used in dyeing, where it is valuable not only as a mordant, but also on account of the clear black which it gives.

Rhizophora mangle, mangrove, is a tree indigenous to all tropical countries, on the banks of rivers and in marshy places. On account of the rapidity and luxuriance of its growth, this tree may become an important source of tannin, which exists in the bark of the root to the extent of twenty to thirty per cent. The great objection to it is that it gives a bad color to leather, which must be corrected by the use of other more expensive astringents.

Acacia decurrens, mimosa, a handsome tree, eighty feet in height, indigenous to Australia and Tasmania, yields a bark very rich in tannin, said to reach as high as forty-two per cent. This material, and an extract of it, has been much used in England, and efforts have been made to encourage the cultivation of this and allied species in the colonies. In five years, the tree will yield a large quantity of bark. It has been suggested to introduce it in this country, and when our supplies from oak, hemlock and chestnut are exhausted, it may become a necessity, but not until then can we look for any artificial sources.

Quebracho (*Loxopterygium Lorentzii*), indigenous to Argentine Republic, yields a bark and wood containing twenty per cent. of tannin. The wood is very hard and is, therefore, to a great extent put in the form of an extract before using in the French markets, where it is very popular. It is claimed for some of these extracts that they contain seventy to seventy-five per cent. of tannin. In

all the above barks, it has been found that the proper time for collection is in the spring, when the sap is flowing. The bark is easily stripped off, and is much richer in tannin than that collected late in the season. It is also well known that trees growing on a limestone soil do not yield as much tannin as those growing on other ground.

Fruits.—Dividivi (*Cæsalpinia Coriaria*), the seed pods of a tree, twenty to thirty feet in height, indigenous to West Indies, Mexico, Venezuela, and north Brazil. The pod dries in the form of the letter S, and contains from thirty to fifty per cent. of a valuable tannin which, however, is depreciated by the other constituents which cause rapid fermentation. On this account, the leather tanned with dividivi is soft, rapidly becomes discolored and spoiled in a damp atmosphere. The use in dyeing is not attended with the same objections, and I have seen them largely used by a dyer in Bradford, England, who told me they obtained from dividivi a better black than from any other tannin material.

Myrobalans (*Terminalia Chebula*).—The fruit of a tree, forty to fifty feet in height, indigenous to India. This, like dividivi, is much used in dyeing and for toning the color of other tanning or dyeing materials. The amount of tannin is from forty to forty-five per cent.

Valonia (*Quercus Ægilops*) —This oak tree grows in the vicinity of the Mediterranean, and we obtain from it the acorn-cup, which, when ground, gives us a most valuable tanning material, imparting to leather both firmness and weight. When used alone, it renders the leather too hard and brittle, so that it is largely used in connection with myrobalans and mimosa.

Leaves.—Sumach is a name applied to various species of *Rhus*. In Europe, the *Rhus coriaria* is the most important, and furnishes to commerce the leaves which are so much esteemed by dyers, and for certain kinds of tanning. This small tree, or shrub, grows extensively in the countries bordering on the Mediterranean, and especially in Sicily. Contrary to the experience in the United States, it is said to flourish best in a limestone soil. From 10,000 to 12,000 tons are said to be annually imported of this variety. Of course, it has been suggested that we cultivate our own, as several species grow wild in this country.

R. glabra and *R. copallina* have been recommended for this in

addition to the Sicilian. Considerable attention has been given to this subject by our Government, and valuable reports were published in regard to it in the Agricultural Reports for 1878 and 1881–82.

The plants are propagated from the young shoots which are found each year about the base of the older plant. These shoots are planted very much in the manner adopted for potatoes, and the cultivation is conducted similarly to that applied to Indian corn. They are planted in the spring, and when well started are cut down to within six or eight inches of the ground. The second summer they will yield a crop of leaves.

The leaves are gathered either by cutting the small branches, or by stripping directly, leaving the small leaves on the ends of the shoots. A plantation is said to yield profitable crops for ten years. The average yield is 2,600 pounds per acre. After the second year, the leaves are more valuable. When the collecting is accomplished by cutting, the branches are allowed to wither, and are then carried to a shed and dried. The drying must be conducted carefully, in order to prevent heating and consequent fermentation and spoiling.

The branches when dry are beaten with a flail, and the leaves separated by sifting. When ground, the leaves are ready for market. The grinding is accomplished by heavy stones set on edge. Virginia is the state in which most attention has been devoted to this industry, and the crop reaches 7,000 to 8,000 tons. There is said to be a difference between the American and European products. The former yields from six to eight per cent. more tannin, but the accompanying yellow or dark color is a great objection to those who wish to have a fine white leather. This color is supposed to be identical with the quercitron in oak bark. The Government chemists have decided that this coloring matter exists in larger proportion in the leaves collected late in the season, consequently it is recommended to collect not later than the last of June. The amount of tannin reaches its maximum in July, but it is thought best to sacrifice this small amount, being 22·75 per cent. in June against 27·38 per cent. in July. The Sicilian product yields 24·27 per cent. of tannin. There are many difficulties in the way of sumach becoming a universal tanning material, a very considerable one is the tendency which the infusion possesses of becoming sour. This has been obviated by the use of extract of sumach,

which has been deprived of much of its coloring matter, and consequently is better in two ways.

The process consists in adding to the thin liquor, which has been run from the extractors into a large tank, oxalic acid in the proportion of one gram to 100 litres: this saturates the lime which has come from the water used in extracting. Gelatinous alumina (aluminium hydrate) is then added in the proportion of 250 grams to 100 litres. On filtering, a clear tannic extract is obtained, which is evaporated in vacuo to the desired consistency. I have examined such an extract, and found it very rich in tannin Mucilage may also be removed by increasing the amount of alumina to four times that above-mentioned. Such a process might be advantageously employed in this country for removing coloring matter from the infusions of sumach, which would admit of the leaves being gathered in July, when the proportion of tannin is the greatest. There are no means of knowing the exact amount of sumach produced in this country, but at least as much is gathered here as is imported, and probably a great deal more. This industry will undoubtedly become a very important one, for when the oak and hemlock fail, we must look to artificial growing for our tannin supply, and sumach is by far the most promising source for this object.

Canaigre root has also been considered as a possible tannin supply. The plant, *Rumex hymenosepalum*, from which the roots are obtained, grow abundantly in a large part of Texas. The roots are in clusters, like sweet potatoes, weighing several pounds, and are quite fleshy, but become much wrinkled in drying. When dried, they are said to yield forty per cent. of tannin, and as at present they grow on waste ground, they are worth our consideration as a supply. There is, however, considerable red coloring matter present, which may limit their use.

Cutch is a dried extract from *Acacia catechu*, a tree thirty to forty feet in height, indigenous to India, Burmah, and East Africa, and from *Acacia suma*, growing in South India and Bengal. The extract is prepared by cutting the trees when they are one foot in diameter, reducing all the woody parts, except the small branches, to chips, and digesting these chips in water in earthen vessels over slow fires. When sufficiently thickened after decantation and further concentration, the extract is poured into rude clay moulds or mats, and allowed to harden, in which form it comes into commerce.

Gambier is another variety, being an extract of the leaves of *Uncaria gambier* and *U. acida*, a climbing shrub indigenous to Ceylon and Sumatra. The leaves and young shoots are exhausted by boiling with water, the decoction is evaporated to the consistence of a syrup, when it is placed in buckets, a man plunges two sticks into two of these buckets, and works them up and down until the mass sets, a result which could not, it is said, be attained in any other way. This thick, yellowish mass, resembling clay, is poured into shallow boxes, cut into small cubes and dried in the shade. The importation of cutch, all varieties, in 1880, reached 23,000 tons, while in 1882 it fell off to 7,000 tons. England imports about 20,000 tons annually of gambier alone.

Polygonum amphibium, water knotweed, has attracted some attention as a source of tannin in Illinois, where it has been used by a few tanneries.

To summarize, it may be said that the future supply of the imported tannin-furnishing materials is not likely to become a concern to us, as the supply is either well nigh inexhaustible, or else the product of cultivation. We cannot afford, however, to depend on foreign supply to furnish material for the tanning and dyeing industries, consequently our own resources must be taken care of, or developed. At present, the hemlock, oak and chestnut give us all we need, but as this supply will soon be exhausted unless provision for a continuation of it is made, we must face the necessity of artificial sources at no distant date.

The sumach has already become a reality among the artificial sources, to be followed by such promising materials as mangrove and mimosa, which, having objectionable features, will have to be studied so as to adapt them to our needs.

A NEW PROCESS OF CASTING IRON AND OTHER METALS UPON LACE, EMBROIDERIES, FERN LEAVES AND OTHER COMBUSTIBLE MATERIALS.

BY A. E. OUTERBRIDGE, JR.

[*Abstract of Remarks made at the Stated Meeting of* THE FRANKLIN INSTITUTE, *Wednesday, April 20, 1887.*]

JOSEPH M. WILSON, President, in the Chair.

MR. OUTERBRIDGE:—The art of making charcoal—if, indeed, so crude a process is worthy of being dignified by the name of an art—dates back to a remote antiquity, and has been practised with but little change for hundreds of years. It is true that some improvements have been recently made, but these relate to the recovery of certain volatile by-products which were formerly lost.

Every one is familiar with the appearance and characteristics of ordinary charcoal, yet I hope to show you this evening that we still have something new to learn about its qualities and the unexpected practical uses to which it may be applied.

We commonly regard charcoal as a brittle, readily combustible substance, but we have before us specimens in which these qualities are conspicuously absent. Here is a piece of carbonized cotton sheeting, which may be rolled or folded over without breaking, and, as you see, when placed in the flame of a Bunsen burner, the fibres may be heated white-hot in the air, and when removed from the flame, the material shows no tendency to consume. Here, again, we have a piece of very fine lace, which has been similarly carbonized, and displays the same qualities of ductility and incombustibility.

These carbonized fabrics may be subjected to much more severe tests with impunity, and, when I tell you that they have been exposed to a bath of molten iron without injury, you will readily admit that they possess some qualities not ordinarily associated with charcoal. When removed from the mould in which they were placed after the iron casting had cooled, not a single fibre was consumed, but *upon the face of the casting there was found a sharp and accurate reproduction of the design, thus forming*

FIG. 1.

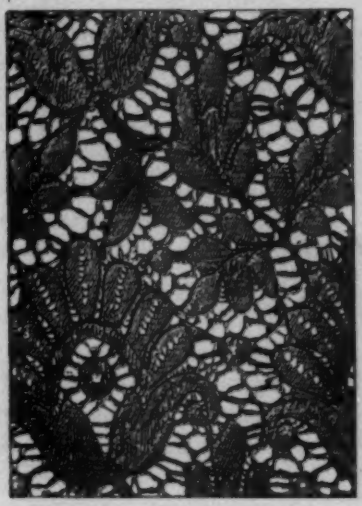


FIG. 2.

FIG. 3.

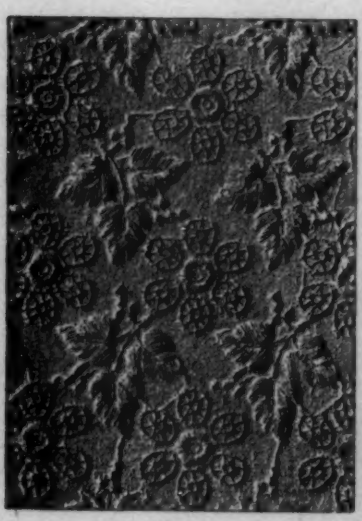


FIG. 4.

NOTE.—*Fig. 1* is photographed from a white iron casting made upon carbonized coarse lace, the lower portion of the plate shows the lace imbedded in the iron. *Fig. 2* is a casting in gray iron upon lace laid on an iron plate. *Fig. 3* is a casting in hard iron upon lace laid on sand. *Fig. 4* is a casting in gray iron upon a piece of thin summer dress goods with machine embroidery.

a die. This die may be used for a variety of purposes, such as embossing leather, stamping paper, sheet metal, etc., or for producing ornamental surfaces upon such castings.

Some of the carbonized fabrics displayed upon the table are almost as delicate as cob-webs, and one would naturally suppose that when a great body of molten metal is poured into a mould in which they are placed, they would be torn to fragments and float to the surface even though they were unconsumed, yet such is not the case. I have found in practice that the most delicate fabrics may be subjected to this treatment without danger of destruction, and that no special care is needed either in preparing the mould or in pouring the metal.

By the aid of the megascope, the enlarged images of some of these castings, showing the delicate tracery of the patterns, will now be projected upon the screen, and you can all see how perfectly the design is reproduced.

In these experiments, the mould was made in "green sand" in the ordinary manner, and the fabric laid smoothly upon one face, being cut slightly larger than the mould, in order that it might project over the edge, so that when the moulding-flask was closed, the fabric was held in its proper position. As the molten metal flowed into the mould, it forced the fabric firmly against the sand wall, and when the casting was removed, the carbonized fabric was stripped off from its face without injury. In this way several castings have been made from one carbonized material.

These castings are as sharp as electrotypes, whether made of soft fluid iron or of hard quick-setting metal. This peculiarity is owing to the affinity between molten iron or steel and carbon, the molten metal tends to absorb the carbon as it flows over it, thus causing the fabric to hug the metal closely. It is somewhat analogous to the effect of pouring mercury over zinc. You know that when mercury is poured upon a board, it runs in a globular form, it does not "wet" the board, so to speak, but when poured upon a plate of clean zinc, it flows like water and wets every portion of the zinc; or, as we say, it amalgamates with the zinc; so when molten iron is poured into an ordinary sand mould, which has been faced with this refractorily-carbonized fabric, it wets every portion of it, tending to absorb the carbon, and doubtless would do so if it remained fluid long enough, but as the

metal cools almost immediately, there is no appreciable destruction of the fibres.

The casting which I shall now exhibit represents a very interesting and novel experiment. In this case, the piece of lace, having open meshes a little larger than a pin's head, instead of being laid upon one face of the mould, was suspended in it in such a way as to divide it into two equal parts. Two gates or runners were provided, leading from the "sinking head" to the bottom of the mould, one on each side of the lace partition, the molten iron was poured into the sinking head and flowing equally through both runners, filled the mould to a common level. The lace, which was held in position by having its edges imbedded in the walls of the mould, remained intact. When the casting was cold, it was thrown upon the floor of the foundry and separated into two parts, while the lace fell out uninjured, and the pattern was found to be reproduced upon each face of the casting.

The question naturally arises, why did not the iron run through the holes and join together? The answer may be found in the fact that the thin film of oxide of iron or "skin," as it is popularly called, which always forms on the surface of molten iron, was caught in these fine meshes, and thus prevented the molten metal from joining through the holes. I have repeated the experiment a number of times, and find that the meshes must be quite small (not over one-fiftieth of an inch) otherwise the metal will reunite.

I think that this observation explains the cause of many obscure flaws found in castings, sometimes causing them to break when subjected to quite moderate strains. We frequently find little "cold shot," or metallic globules, imbedded in cast iron, or steel, impairing the strength of the metal, and it has long been asked, "What is the cause of this defect?" The pellicles have been carefully analyzed, under the supposition that they might be alloys of iron and nickel, or some other refractory metal, but the analysis has failed to substantiate this theory. Is it not probable that in the process of casting little drops of molten metal are sometimes splashed out of the stream, which immediately solidify and become coated with a skin of oxide, then falling back into the stream of rapidly cooling metal, they do not remelt, neither do they weld or amalgamate with the mass owing to this protective coating, thus forming dangerous flaws in the casting?

The process of carbonizing the delicate fabrics, leaves, grasses, etc., is as follows: the objects are placed in a cast-iron box, the bottom of which is covered with a layer of powdered charcoal or other form of carbon, then another layer of carbon dust is sprinkled over them, and the box is covered with a close-fitting lid. The box is next heated gradually in an oven, to drive off moisture, and the temperature slowly raised until the escape of blue smoke from under the lid ceases, the heat is then increased until the box becomes white hot, it is kept in this glowing condition for at least two hours; it is then removed from the fire, allowed to cool, and the contents are tested in a gas flame. If they have been thoroughly carbonized, they will not glow when removed from the flame, and the fibres may even be heated white hot before consuming.

Of course, the method employed to carbonize the materials is suspectible of variation, but the scientific principles involved are unchangeable, viz.:

(1.) Partial exclusion of air and substitution therefor of a carbon atmosphere.

(2.) Slow heating to drive off moisture and volatile elements.

(3.) Intense and prolonged heating of the partly charred objects to eliminate remaining foreign elements, and to change the carbon from the combustible form of ordinary charcoal to a highly refractory condition.

EDITOR'S NOTE.—The description of this novel process elicited some interesting discussion, and the exhibition of fine castings on the delicate fabrics called forth much approbation. Several practical applications of the process have been suggested.

NOTE ON THE MODIFICATIONS OF THE BESSEMER STEEL PROCESS.

BY C. HANFORD HENDERSON.

[*Abstract of a Lecture, delivered before the* FRANKLIN INSTITUTE, *Monday, January 3, 1887.*]

In the ordinary pneumatic steel process, there are four elements which are susceptible of essential modification. These are:

(1.) Shape of the converter.
(2.) Nature of lining.
(3.) Composition of metallic charge.
(4.) Composition of blast.

In glancing over this table, it may possibly be thought that two very important factors have been omitted,—those of time and temperature. But they are both involved in the four elements cited. The time of the reaction will depend upon the chemical composition of the lining, of the metallic charge and of the blast. It is assumed in each case to be such as will give the best results. The temperature at which these reactions occur is dependent upon the calorific power of the oxidizable elements, and is therefore quite beyond our control when once the composition of the metallic bath has been decided upon.

In the regular Bessemer process, the shape of the converter, it will be remembered, is simply that of a bulging vase, with the tuyères or blast holes in the bottom. The vessel is generally movable about a horizontal axis through 180°, but occasionally it is fixed. Since the chemical reactions are the same in both cases, however, these differences of construction are in no sense distinctive, and may be omitted from such a general consideration as the present. The lining of the converter is of gannister, and consequently highly acid. During the progress of the "blow," the molten oxide of iron, coming in contact with the silica of the lining, unites with it to form a fusible slag of silicate of iron. As the lining furnishes an unfailing supply of silica, there is always an excess of that element available, and the slags in the regular Bessemer operation are invariably very acid. The phosphorus in the

pig iron is therefore all retained in the resultant steel. It manifests itself in even higher proportion than in the original crude material, since there is a loss of about ten per cent. during the transformation of iron into steel. The nature of the lining has given the name of acid process to the typical Bessemer operation. This designation is now in constant use in order to distinguish the older process from the basic process, invented by Messrs. Thomas and Gilchrist. The metallic bath in the regular Bessemer consists of a very pure pig iron, containing from 0·77 to 3·0 per cent. of silicon, and from 3·50 to 4·70 per cent. of carbon, with but traces of phosphorus and sulphur. The blast used to burn out the carbon and silicon from the pig metal is simply air, just as it exists in the atmosphere.

Such are the four elements that go to make up the Bessemer process. The modifications of that process, which are possible, will all come under the several headings given, and may advantageously be considered in the order in which the elements have been mentioned. At the present time, these modifications possess more than a passing interest, since several of them are of large importance, commercially. Much ingenuity has been expended in the effort to so vary the shape of the converter that a new and distinctive process might be announced. But, in spite of the fancied merits claimed for these inventions, they are, for the most part, modern revivals of old and discarded devices. At the October meeting of the British Iron and Steel Institute, Sir Henry Bessemer read a very interesting paper, in which he described some of the earlier forms of his converter. The diagrams which he exhibited, showed conclusively that he had, at the very inception of his process, made an exhaustive study of the possibilities in the direction of form. Many of the modified converters now being brought forward by later patentees are almost exact reproductions of those abandoned by Bessemer years ago, on account of their manifest inferiority to the typical vessel which bears his name. It would, therefore, be a fruitless inquiry to consider all of the varied shapes which have been impressed upon the pneumatic steel converter. At the present time, there is but one modification which has any strong claim upon the attention of American metallurgists, and that is the form introduced into this country under the name of its British patentees, Messrs. Clapp and

Griffiths, but which, in reality, owes whatever orignality it may possess to its American adapter, Mr. James P. Witherow, of Pittsburgh. The importance of even this converter is commercial rather than technical. While the history of its development here may show that under certain economic conditions, it possesses advantages over the usual Bessemer plant, a candid examination of the Clapp-Griffiths vessel fails, I think, to discover any features which sufficiently differentiate it from the typical Bessemer converter to permit one to rank the operations carried out in it as a distinctive process.

Briefly described, the Clapp-Griffiths converter is a stationary vessel having the tuyère holes in the side some distance above the bottom, and provided above these with a charging door and open slag hole. Its capacity varies from a few hundred pounds of metal to several tons. In general, the preference is given to small charges, or to such as do not exceed two or three tons. The essential features in its operation are the side-blowing and the continuous slagging. It is of no importance that the vessel is stationary, since it is not always so constructed, and since the regular Bessemer converter used in several Swedish localities is of the same design. The Clapp-Griffiths blow is characterized by the almost immediate appearance of copious reddish-brown fumes of oxide of iron, indicating an early oxidation. As the molten bath stands only about eight inches above the level of the tuyères, the blast has a comparatively shallow depth of metal to penetrate. As a result of this construction, large quantities of iron are readily oxidized and the slags formed have a much higher basicity than is customary in the regular Bessemer practice. The open slag-hole, by permitting the removal of the slag during the boil, also favors this result. By withdrawing the silicate of iron as it forms, an excess of oxide of iron is ensured, and the conditions for the subsequent reduction of the silicon are made less favorable. The resultant metal is consequently low in both carbon and silicon. It contains, however, nearly all of the phosphorus carried by the original pig iron. It is a recognized fact in the metallurgy of steel that phosphorus becomes, if not entirely innocuous, at least a much less undesirable constituent when dissociated from carbon and silicon. This is believed to be the explanation of the remarkable physical tests endured by highly phosphoric samples of Clapp-

Griffiths metal, for it is invariably low in silicon. Captain Hunt's much quoted results showed that steel containing as much as one-half of one per cent. of phosphorus was in reality an admirable material if only carbon and silicon were reduced to a minimum. But whether the deeply-rooted prejudice against phosphoric products made them unpopular, or whether the difficulties in the way of their introduction were of a more inherent nature, it would be hard to say. At the present time, however, pig irons of more than moderate phosphoric content are not being employed by the Clapp-Griffiths plants. The result of blowing a charge in such a converter may be stated then to be a soft ingot iron which is of better quality for the same grade of pig metal than if blown in the larger vessel. So much for the product, but we want more particularly to know about the process. The pertinent question presents itself as to whether the same result might not have been obtained by a more careful attention to the conditions in the typical Bessemer converter. The question will best be answered by observing the result obtained at plants where the conditions are more nearly comparable with the conditions prevailing in the Clapp-Griffiths. Such a comparison has been made easy by Prof. Drown, who, in his paper on "The Little Bessemer," cites the results from a number of European establishments, where the blowing of small charges is regularly practiced. From this it appears that while the behavior of highly phosphoric pig metal in acid-lined converters, other than the Clapp-Griffiths, has not been made the subject of inquiry, the same minima of carbon and silicon in the resulting steel is obtainable if care is taken to maintain an excess of oxide of iron in the slag, by having but a small depth of metal above the tuyéres. In the large Bessemer converter, blowing charges of ten or fifteen tons, low silicon is sometimes produced, but it cannot be depended upon, while in the little Bessemer such a result may be made invariable.

But while the Clapp-Griffiths is a modification in no way distinctive, either in its mechanical features or in the quality of its product, it has an importance, commercially, which must not be lost sight of. The first cost of the plant is comparatively small, and will frequently justify its erection under circumstances which would otherwise be prohibitive. It is improbable that it will ever be able to compete with the regular process in the production of

the larger articles in the steel industry, but as an adjunct to the blast furnace, for transforming the product into ingot iron or steel, or for supplying a special market, removed some distance from the great centres of steel production, the future apparently offers many encouraging possibilities. It is, I think, detracting nothing from the just rank of this converter, and the process carried out in it, to consider it simply a judicious adaptation of the small vessel to the needs of our home metallurgy. But whether it fulfil its present promise of usefulness in this country or not, American engineers have certainly been placed under much obligation to those who have, in the face of many difficulties, introduced the process here, and brought about the current and widespread discussion concerning the influence of early oxidation of the iron, and of mass, in determining the qualities of the resultant steel.

In considering the modification of the Bessemer practice, due to a changed lining of the converter, we are brought to a process which, by virtue of its characteristic chemical reactions, is entitled to the rank of a distinct invention. Its importance may be judged from the fact that over 1,000,000 tons of steel are now annually manufactured by the works where it has been introduced. In the regular Bessemer operation, as has been stated, the lining of the converter is highly acid, and, in consequence, no phosphorus is eliminated from the pig metal during its conversion into steel. This condition limited the crude material available for the process to the irons containing little or no phosphorus. To so modify the conditions, that an acceptable steel could be made from phosphoric pig metal, has been the chief problem before the metallurgical world since the first announcement of Bessemer's great discovery, but its solution was not accomplished until 1878.

In that year, Mr. Sidney Thomas announced to the British Iron and Steel Institute that he had, with the co-operation of Mr. Percy Gilchrist effected the removal of phosphorus in the Bessemer converter, by substituting a basic lining for the usual gannister. When phosphoric pig metal is subjected to a blast of air, the phosphorus oxidizes and forms phosphate of iron, but at the high temperatures prevailing in the converter, it is readily replaced by silicon, if that element be present, and is again reduced to phosphide of iron This fact was well known to metallurgists, but the simple expedient of preventing the subsequent reduction of the

phosphorus, by keeping silicon out of the way, does not seem to have made much impression upon them, until Messrs. Thomas and Gilchrist carried out the suggestion experimentally and demonstrated its entire practicability as an industrial operation. In the process, which bears their name, the converter is of the usual form, and is lined with burnt dolomite, a mixture of the oxides of calcium and magnesium. The metallic charge differs in containing but very small amounts of silicon, and carrying preferably about three per cent. of phosphorus. From twelve to fourteen per cent. of lime is thrown into the converter just before the introduction of the metallic charge. The progress of the blow in the basic operation is precisely the same as in the regular Bessemer, except that the charge is subjected to an "after-blow," during which the elimination of the phosphorus is accomplished. On account of the low percentage of silicon, the Bessemer blow, as it is termed to distinguish it from the after-blow, requires much less time than ordinarily, occupying frequently not more than about eight minutes. Another consequence of the low silicon is that the charge is apt to blow cold. It is, therefore, customary to heat the pig metal in a regenerative furnace before its introduction into the converter, so that the initial temperature may be as high as possible. When the flame drops, indicating the complete removal of carbon, the blast is continued for, perhaps, five minutes longer, or in general, about two-thirds of the time required by the Bessemer blow. During this period, the appearance of the flame remains unchanged, and the spectroscope shows only the sodium line. The termination of the after-blow is indicated by no marked reaction. It must be determined entirely by special tests. A sample of the steel is taken from the converter, rapidly cooled and the fracture subjected to a careful examination. To the practiced eye, the crystalline structure follows very closely the phosphoric content, and may frequently supplant chemical analysis. In Silesia, the deepening color of the slag is made the criterion of the progress of the after-blow. When this is ended, from one-half to one per cent. of ferro-manganese (eighty per cent. manganese) is added to recarbonize the charge. The ferro-manganese is generally heated, and half added in the converter and the remainder in the ladle; but these smaller details of management naturally vary at each establishment. The *rationale* of the Bessemer blow is too well

known to require comment, but the after-blow is a less familiar operation. The following analyses, obtained from gentlemen who have spent some months in experimenting with the basic process, will offer a good foundation for discussing the reactions of the after-blow:

CONVERTER LINING.

Silicon,	2·00
Magnesia,	29·50
Lime,	62·60
Iron and alumina,	1·30
Moisture and carbon dioxide (by difference),	4·60
	100·00

PIG METAL.

Silicon,	·60
Sulphur,	·05
Phosphorus,	2·50
Manganese,	·25
Carbon,	3·50
Iron (by difference),	93·10
	100·00

BASIC FLUX.

Lime,	93·80
Magnesia,	3·00
Silica,	1·50
Iron and alumina,	1·20
	99·50

BASIC STEEL.

Carbon,	·06
Silicon,	·01
Sulphur,	·05
Phosphorus,	·06
Manganese,	·25
Iron (by difference),	99·57
	100·00

BASIC SLAGS.

	I.	*II.*	*III.*	*IV.*
Silica,	7·20	16·00	6·00	8·43
Phosphorus,	7·42	5·49	7·80	8·31

When the Bessemer blow ends, the metal in the converter consists of an almost completely decarbonized and desiliconized iron carrying from three to four per cent. of phosphorus. During the

after-blow this element is oxidized and becomes the heat producer of the operation. Phosphate of iron is formed and floats upon the bath as a fusible slag. The iron, however, is speedily displaced by the more powerful bases, lime and magnesia. The comparative absence of silicon, for it will be noticed that in lining, pig metal and flux, the amount of that element has been reduced to a minimum, prevents the subsequent reduction of the phosphorus and its combination with the iron as a phosphide. The product of the basic operation is a very soft steel containing not excessive amounts of phosphorus. The economic feature of the process is the production of an excellent steel from a cheap pig iron; perhaps its greatest disadvantage, the difficulty of maintaining a sufficiently high temperature in the presence of such low silicon.

In the conduct of the process, the lining for the converter is prepared by mixing the ground dolomite with about eight per cent. of anhydrous tar. The Holley movable bottom is used in the most modern establishments, the tuyères being constructed of fine clay as in the ordinary process. The average life of the bottoms is forty blows, and of the vessel itself twice that number. It is very desirable that the pig iron shall be high in phosphorus, since the final heat and consequent fluidity of the steel depend upon the oxidation of this element. In the analysis quoted, the phosphorus was only two and one-half per cent., but three, or even three and one-half per cent., is preferable. The slags from the basic process possess no little value for the manufacture of super-phosphates. They find always a ready market, as it requires only fine grinding to make the phosphorus directly available as a plant food.

At the present time, the Thomas-Gilchrist process is in active operation in Germany, Austria, England, France, Belgium and Russia; in all of the great iron-producing countries, indeed, except the United States. It is an open secret that experiments are now in progress in this country, but as yet the operations in this direction have been decidedly spasmodic. The abundance of Bessemer ores can scarcely be adduced as an explanation of the cause of this lack of development, since phosphoric ores, it need hardly be said, are far more abundant, and sufficiently lower in price to make their utilization a profitable operation. Particularly is this the case in the South, and southern iron-masters are finally turning their attention to the basic process as the probable

development best suited to their local conditions. The cause of American inaction is rather to be found in the litigation, which unhappily surrounded the process in this country from almost the first day of its announcement.

The third direction in which the Bessemer process may be modified, is in the composition of the metallic bath, but no distinct process has been founded upon this variation. It is involved alike with the changed lining in the basic operation, since the pig metal must necessarily be low in silicon and high in phosphorus. Nor has the possibility of changing the composition of the blast been as yet more productive in giving us a practical modification. In the earlier days of the process, a number of suggestions were brought forward for replacing the air in whole or in part by hydrogen gas and by steam, the idea apparently being that the affinity of hydrogen for phosphorus and sulphur would cause a union with those elements and partially remove them in the form of gases. But while nascent hydrogen at lower temperatures readily effects the decomposition of solid phosphides and sulphides, carrying off the phosphorus and sulphur in the form of phosphuretted and sulphuretted hydrogen, the unstable character of these products leaves little ground for hope that such reactions could be made of any value in the Bessemer converter. Experiments made in this direction have never met with any success, but since nothing is so sure as the unexpected, it would be premature to affirm that the field had been exhausted.

It is apparently the tendency in modern Bessemer practice to produce steels low in silicon and carbon, to replace as far as possible wrought-iron as a constructive material. It is always dangerous for the worker in the laboratory and among books to predict what his brother-worker at the furnace will or will not do, but if one who stands afar off may presume to judge, the possibility which will attract the study of future steel-makers, will be the production of a neutral lining permitting basic or acid slags at pleasure.

Philadelphia Manual Training School, January 3, 1887.

THE CASTNER SODIUM PROCESS.

BY MR. JAMES MACTEAR, F.C.S.

[*An Address read at the meeting of the Society of Chemical Industry, London, March 7, 1887.*]

Having been engaged professionally during the past few months in assisting in the development of this process, through the kind permission of Mr. Castner, I am enabled to present to this Society, its details, together with a few facts concerning the uses and cost of manufacturing sodium and potassium.

The process heretofore exclusively used for the production of these two metals is so well known that anything more than a brief reference is hardly necessary in this paper.

By the older process, carbonate of soda, charcoal, and lime, in proportion of thirty, thirteen and seven, are made into the finest and most intimate mixture, and then calcined at a red heat to render the mixture more compact, which also expels a considerable amount of carbonic oxide. This calcined mixture is then introduced into wrought-iron cylinders of small diameter, and heated to a temperature of about 1,400° C., whereby the alkaline metal is reduced and distilled from the cylinder containing the charge, through a small tube provided for the gases and vapors, into the receptacle known as the condenser. Through a variety of causes, not more than forty per cent. of the metal contained in the charge is obtained, and in the manufacture of potassium very much less. The wear and tear on the metal cylinders is enormous, and forms a large proportion of the cost of manufacture. To arrive even at these results, requires—

(1.) The most careful grinding and mixing of ingredients.

(2.) The addition of lime to prevent fusion.

(3.) An excess of carbon to ensure contact between the particles of soda and carbon in the refractory charge.

(4.) Previous calcination to make the charge less bulky.

(5.) Wrought iron must be used in constructing the cylinders, being the only available metal that will stand the high temperature.

(6.) Cylinders must be used for small diameter, so as to allow the heat to penetrate to the centre of the refractory charge.

(7.) The exit tubes from the cylinders to the condensers require the most careful attention, to keep them open, owing to the formation of the black compound, formed by the action of carbonic oxide upon the vapor of the alkaline metal, which combination takes place at about the condensing point of the metallic vapor. This is one of the most serious obstacles to be met with in the course of manufacturing sodium, not only causing a large loss of metal, but interfering generally with the operation. In the making of potassium, the formation of this compound, which is exceedingly explosive, and which is produced even more readily than when making sodium, is the chief reason that this metal costs almost ten times as much as the same quantity of sodium.

As nearly as I can ascertain at present, sodium costs about four shillings per pound to produce, the following being the chief items:

	s.	*d.*
Wear and tear to furnaces, cylinders, etc.,	2	0
Materials—owing to loss and waste,	1	0
Labor,	0	8
Fuel,	0	4

Since Mr. Castner's paper upon his process, which was read* before the FRANKLIN INSTITUTE of Philadelphia, October 12, 1886, several slight changes in the mode of carrying on this process have been made. These have been brought about by the experience gained from the actual working of the process upon a commercial scale.

The reactions by which the sodium and potassium are produced are difficult to describe, as they vary somewhat according to the mixture of materials and temperature employed in the reduction. The mixture and temperature which it is now preferred to use, is represented by the reaction:

$$6\ Na\ HO + Fe\ C_2 = 2\ Na_2\ CO_3 + 6\ H + Fe + 2\ Na$$
$$6\ KHO + Fe\ C_2 = 2\ K_2\ CO_3 + 6\ H + Fe + 2\ K$$

In place of using an actual chemical compound of iron and carbon, as expressed by the above reaction, a substitute or equivalent is prepared as follows: To a given quantity of melted pitch is added a definite proportion of iron in a fine state of division. The mixture is cooled, broken up into lumps and coked in large crucibles, giving a metallic coke, consisting of carbon and iron, the proportions of each depending upon the relative quantities of pitch

* See this JOURNAL, **122**, 347.

and iron used. This metallic coke, after being finely ground, provides a substance having the iron and carbon in a like proportion to an iron carbide, and from which neither the iron nor carbon can be separated by mechanical means. The fine iron is conveniently prepared by passing carbonic oxide and hydrogen in a heated state, as obtained from an ordinary gas producer, over a mass of oxide of iron, commercially known as "purple ores," heated to a temperature of about 500° C.

In producing sodium, caustic soda of the highest obtainable strength is used, and there is mixed with it a weighed quantity of the so-called "carbide," sufficient to furnish the proper amount of carbon to carry out the reaction indicated above. The crucibles in which this mixture is treated are made of cast steel, and are capable of containing a charge of fifteen pounds of caustic soda, together with the proper proportion of the "carbide."

After charging a crucible with the above mixture, it is placed in a small furnace, where it is kept at a low heat for about thirty minutes, during which time the mass fuses, boils violently, and a large part of the hydrogen is expelled by the combined action of the iron and carbon, the "carbide," owing to its gravity, remaining in suspension throughout the fused soda. At the end of the time stated, the contents of the crucible have subsided to a quiet fusion. The crucible is then lifted, by a pair of tongs on wheels, placed upon the platform of the elevating gear, and raised to its position in the heating chamber in the main distilling furnace. The cover which remains stationary in the furnace has a convex edge, while the crucible has a groove round the edge, into which the edge of the cover fits. A little powdered lime is placed in the crucible groove just before it is raised, so that when the edges of the cover and crucible come together, they form a tight joint, and, at the same time, will allow the crucible to be lowered easily from the chamber when the operation is finished, to give place to another containing a fresh charge. From the cover projects a slanting tube connected with the condenser. The condenser is provided with a small opening at the further end, to allow the escape of hydrogen and has also a rod fixed by means of which any obstruction which may form in the tube, during distillation, may be removed. After raising a crucible in its place in the furnace, the hydrogen escaping from the condenser is lighted, and

serves to show by the size of the flame how the operation is progressing in the crucible, the sodium actually distilling soon after the crucible is in its place. The temperature of the reduction and distillation has been found to be about 823° C. The gas coming off during the first part of the distillation, has been analyzed and found to consist of pure hydrogen. An analysis of the gas sample taken when the operation was almost completed, gave as a result, hydrogen ninety-five per cent, carbonic oxide five per cent. It has been found advisable to use a little more "carbide" than the reaction absolutely requires, and this accounts for the presence of the small quantity of carbonic oxide in the expelled gas, the free carbon acting upon the carbonate formed by the reaction, thus giving off carbonic oxide, and leaving a very small percentage of the residue in the form of peroxide of sodium. This small amount of carbonic oxide rarely combines with any of the sodium in the tube, and so the metal obtained in the condensers is pure, and the tubes never become choked with the black compound. In the preparation of potassium a little less "carbide" is used than the reaction requires, thus no carbonic oxide is given off, and all danger attached to the making of potassium is removed. After the reduction and distillation, the crucible is lowered from the furnace, and the contents poured out, leaving the crucible ready to be recharged. The average analyses of the residues show their composition to be as follows:

	Per Cent.
Carbonate of soda,	77
Peroxide of sodium,	2
Carbon,	2
Iron,	19

The average weight of these residues from operating upon charges of fifteen pounds of caustic soda, and five and one-fourth pounds of carbide, is sixteen pounds. These residues are treated either to produce pure crystallized carbonate of soda or caustic soda, and the iron is recovered and used again with pitch in the formation of the "carbide." From this residue, weighing sixteen pounds, is obtained thirteen pounds of anhydrous carbonate of soda, equivalent to 9·4 pounds caustic soda of seventy-six per cent.

Operating upon charges as above mentioned, the yield has been:

	Pounds.
Sodium, actual,	2·50
" theory,	2·85
Soda, carbonate, actual,	13·00
" " theory,	13·25

The average time of distillation in the large furnace has been one hour thirty minutes, and as the furnace is arranged for three crucibles, forty-five pounds of caustic soda are treated every ninety minutes, producing seven and one-half pounds of sodium and thirty-nine pounds of carbonate of soda. The furnace is capable of treating 720 pounds of caustic soda daily, giving a yield, in twenty-four hours, of 120 pounds of sodium and 624 pounds of anhydrous carbonate of soda. The furnace is heated by gas, which is supplied by a Wilson gas producer, consuming one cwt. of fuel per hour. The small furnace, in which the crucibles are first heated, requires about one-half cwt. per hour. The following estimate of cost, etc., is given from the actual running of the furnace working with the above charges for twenty-four hours:

	£.	s.	d.
720 pounds of caustic soda @ £11 per ton, ...	3	10	10
150 " " "carbide" @ ½d. per pound, . . .	0	6	4
Labor, ...	1	0	0
Fuel, ...	0	17	0
Re-converting 624 pounds of carbonate into caustic at a cost of about £5 per ton on the caustic produced, say, ...	1	0	0
Total, ...	£6	14	2
Deducting value of 475 pounds of caustic recovered, .	2	6	8
Cost of 120 pounds of sodium, ...	£4	7	6

Cost per pound, 8¼d.

Regarding the item of cost relating to the damage caused to the crucibles by the heat, this question has been very carefully gone into. Some of the crucibles have been used upwards of fifty times, and from present indications of their condition, there is no doubt that they can continue to be used at least 150 times more before they become unfit for further use. In considering 200 operations to be the life of a crucible, the item of damage, or wear and tear, amounts to less than one pence per pound on the sodium produced, and, if we take the furnace wear and tear at the same rate of one pence per pound, we will see that the wear and tear of plant is only one-twelfth of that incurred in the ordinary process. It is upon these facts that Mr. Castner bases his claim to be able to produce sodium by his process, upon the large scale, at a cost of less than one shilling per pound. The advantages of this process will be apparent

to anyone at all familiar with the manufacture of these metals as conducted heretofore. The first and most important end gained is their cheap production, and this is owing chiefly to the low heat at which the metals are produced, the quickness of the operation, non-clogging of the conveying tubes, and a very small waste of materials. The process furthermore admits of being carried on upon a very large scale, in fact it is intended ultimately to increase the size of the crucible, so as to make the charges consist of fifty pounds of caustic soda. Crucibles of cast iron have been found quite suitable, and it is intended in future to use crucibles made of this material in place of the more expensive steel.

As regards potassium, it has hitherto been regarded very much as a chemical curiosity, and sells for about sixty shillings per pound. By this method the cost of the manufacturing operations is no more than for sodium, the higher cost of the caustic potash being the chief element of increased expense. The uses of these alkali metals are at present limited, owing to their high cost alone. Sodium is used somewhat largely in manufacturing aluminium, magnesium, silicon, etc., and in the formation of amalgams, while potassium is only used in small quantities as a chemical reagent. It will hardly be considered out of place, in concluding this paper, relating to the manufacture of sodium and potassium, to mention some few facts connected with aluminium. This metal depends at present upon sodium for its production, and consequently any process successfully producing *cheap* sodium in reality allows of the manufacture of *cheap* aluminium. Notwithstanding all the efforts that have been made by various chemists and metallurgists for the past thirty years in endeavoring to invent some process for producing aluminium, whereby that most interesting and valuable metal could be cheaply produced by a better process than that of Deville, absolutely nothing has been accomplished that would even lead one to hope that sometime in the future his process would be superseded. By employing Deville's process and using sodium as heretofore manufactured, the aluminium costs between thirty and forty shillings per pound. Owing to this high price alone, the consumption is limited, and therefore the manufacturer is obliged to ask in selling the metal a relatively higher price in order to obtain anything like a fair profit upon the invested capital. The present selling price of aluminium varies between fifty and sixty shillings per pound,

although every few months there appears in some newspaper the information that some parties (*unknown*) have contracted with other parties (*unknown*) for a large quantity of aluminium at prices varying between ten and thirty shillings per pound. It is needless to say that upon enquiring the contracting parties cannot be found.

Aluminium, if placed upon the market at twenty shillings per pound, could undoubtedly be sold in large quantities, the demand rapidly increasing as the metal gained in favor, which, owing to its varied valuable properties, it would do to a certainty. It is conceded by all those familiar with the different items of cost in carrying out Deville's process, that, could sodium be obtained for one shilling per pound, aluminium could be made below a cost of fifteen shillings per pound.

I think it is not therefore too much to claim for the "Castner Process" of manufacturing sodium and potassium—now that it has been demonstrated commercially capable of producing sodium at one shilling per pound—that it is the greatest advance in the direction of producing aluminium at a cheap rate, which has been made since Deville first demonstrated the possibility of producing that metal on a commercial scale.

It has long been known that the distillation of the metal sodium, is rendered more easy by the use of a proportion of potash in the mixture. It is also known that a series of alloys of potassium and sodium can be produced, several of which are liquid, having much the same appearance as mercury when under naphtha. These alloys are very curious, one of them remaining liquid at 0° C.; while another is lighter in its specific gravity than naphtha, upon which it floats.

Specimens of several of these alloys, together with samples of the sodium and potassium as made by this process, are upon the table, for your inspection.

On RANSOME'S IMPROVEMENTS in the MANUFACTURE of PORTLAND CEMENT.*

By R. J. Friswell, F.I.C., F.C.S.

Portland cement is composed of lime, silica and alumina in proportions approaching sixty, twenty-three and eight respectively; the remaining nine per cent. consisting of various non-essential substances, such as ferric oxide, three to five per cent.; calcium sulphate, 1·0 to 3 0 per cent.; clay and sand, 1·5 to 2·5 per cent.; together with varying quantities of magnesia, potash and soda, making between them about 2·5 per cent. It is what is known to technologists as a hydraulic lime or mortar, *i. e.*, one that possesses the valuable property of hardening under water, which it owes to the more or less intimate combination between the lime, silica and alumina present.

The orginal of this now world-renowned building material was the so-called "Roman" cement, first made by mixing the volcanic tufa of Puzzuoli, near Naples, with ordinary slacked lime. This tufa in its composition closely resembles burnt clay, and hence the idea of mixing clay with chalk and then burning the mixture gradually developed in succession to the burning of natural calcareous stones, such as the septaria nodules of the London clay beds, from which the English-made Roman cement was first produced. This comparatively easy step was patented by Mr. Aspdin, about the year 1824, who started works at Leeds, thus laying the foundations of the present enormous trade now principally centred round the valleys of the Thames and Medway. The process as it at present exists may be briefly described as follows: Chalk is mixed with the requisite quantity of clay in a "wash mill," a large circular basin of brick-work, in which a series of heavy iron drags or harrows are caused to rotate by the motion of a central spindle, to which they are suspended by radiating arms. Water is run in, and the two materials gradually disintegrate and thoroughly mix. The mixture, in the state of thin slop, known as "slurry," runs out of the mill as it is formed, and is led off to large settling tanks

* Reprinted from *The Engineer*, London, March 4, 1887.

or ponds where it is allowed to remain at rest. The finely-divided chalk and clay settle down to a stiff mass at the bottom, and the water is run off; a series of tanks being so arranged that each one is ready for subsequent treatment about six weeks after it has been filled. The stiff mass, or "compo," left behind when the water has run off, is in many works removed and ground in an ordinary mortar mill, after removal from which it is loaded on to drying floors, which are heated, either with waste heat from kilns or coke ovens, or by special furnaces arranged for the purpose. A shed open at the sides protects the drying compo from rain, and it gradually solidifies into masses containing only a small percentage of moisture. These masses, varying from the size of a man's head to that of a fist, are placed in a kiln with alternate layers of coke. A fair-sized kiln will hold seventy tons of dried slurry, fifteen tons of coke, and a small quantity of brushwood to act as kindling.

The fire is now lighted, and by the fourth day, or in, say, ninety-six hours, the eighty-five tons of material have reached a temperature closely approaching that of molten cast iron, and have also diminished in weight to about thirty tons, plus the weight of the ashes of the coke (fifteen cwt.). The kiln requires a day to cool, another day to unload, and the thirty tons of hard cement clinker is ready to be crushed, and then ground into a marketable product. In addition to the above process, there are two modifications of the preliminary part of it in use, known respectively as the "semi-dry" and "dry" processes. These apply a less quantity of water in the mixing of the materials, the object being to do away with the settling tanks, and thus save space and labor. The treatment of the product in the kiln is, however, the same in all. It will be as well here to consider what has happened during the burning described above, and the first striking fact is the enormous decrease in weight. Firstly, the whole of the combustible portion of the coke has gone, mostly in the form of carbonic acid; secondly, the seventy tons of slurry have diminished to about thirty tons.

As far as the coke is concerned, assuming that ninety-five per cent. is carbon, the conversion of this into carbonic acid has involved the consumption of nearly thirty-eight tons of oxygen, equal to nearly 166 tons of air; next, the slurry has lost forty tons, thirty-eight tons being carbonic acid, and the atmosphere has thus

received from the kiln some ninety tons carbonic acid, 128 tons of nitrogen, and about two tons of water in the shape of steam. When the last of the coke has burned away, there is left in the kiln thirty tons of cement clinker at a temperature of over 2000° F., the walls of the kiln have also, for some distance from the interior, been heated to the same degree, and before anything can be done this mass must have become cool enough for removal. It is obvious that the heat retained after the clinker is formed is lost during this cooling process. The value of this heat is considerable, and would probably be equal to nearly one-third of the total coke consumed. In other words, it may be assumed that to re-heat thirty tons of clinker with the brick-work of the kiln would take five tons of coke. If this heat could be utilized, it would effect a saving of, say, two shillings per ton of cement made. Another defect of the process arises from the large size of the lumps of slurry put in. Owing to this they invariably consist of (1) an over-burnt exterior skin, (2) a properly-burnt inner part, (3) if at all large, of an under-burnt kernel. All these are of necessity ground together, since it is impossible to do more than make a very rough selection for the mill.

The clinker now cooled and ready for the mill is extremely hard. It has first to be crushed by a Blake's or other crusher to lumps about the size of a walnut, and these have to be ground under millstones. The extreme hardness of the material necessitates constant redressing of the stones to such an extent that at least a quarter of the stones in a cement mill are always "up" undergoing this process. Thus, while the steam-power required to deal with so refractory a material is a very heavy item, it is obvious that the maintenance of the mill in a thoroughly efficient state involves a constant and serious outlay. Another defect arises from the ash of the coke, which, being inextricably mixed with the cement clinker, is therefore ground with it and acts so far as an adulterant.

Returning to the kiln, we find that each firing involves the heating of the cold walls of the kiln to the necessary temperature, and again cooling them to the point at which it can be unloaded and again loaded up. The kilns have to be built of enormously massive masonry, to withstand the strains and racking caused by these constant violent changes of temperature. To keep them in

repair involves very heavy outlay, and the first cost of a thirty-ton kiln, of about 20 feet diameter and 35 feet to 40 feet high, with walls tapering from about three feet, with its fire-brick lining, is extremely heavy. The ground space occupied by it is also very large.

It will be seen from the above, that the processes of burning and grinding the cement are by far the most costly of all the operations involved in its manufacture, and that they are beset with defects, both scientific and practical, of a very serious nature. It is evident that if any great improvement is to be effected in the manufacture, that to these portions of the process the most serious attention must be directed. It is, therefore, to this part of the work that Mr. Ransome has directed his attention; taking as his guiding principles, economy of fuel, space and labor, he has devised the following process.

The slurry prepared by any one of the methods now in use, is dried on a floor heated as usual, or by waste gas from subsequent processes. The soft, friable and easily-crushed blocks are now reduced to coarse powder, and are then ready for burning. The old kiln is totally abolished, and in its place a cylinder of boiler-plate is used. This is lined with good refractory fire-brick set in fire-clay, and about every fourth row of bricks is set up on end, thus producing a number of parallel longitudinal feathers or ridges extending completely through the cylinder from end to end. The outside of the cylinder is provided with two smooth rings or rails of iron. In the centre a third rail is wrought into teeth, into which a worm rotated at a slow speed, gears. The two rails rest on friction rollers, and the whole cylinder being set at an angle with the horizon is caused to rotate slowly. This construction, though sounding somewhat formidable, is in practice extremely simple, and similar machines, known as "black-ash revolvers," or "revolving black-ash furnaces," have long been, and are now, in daily use in alkali works. The cylinder is mounted on the top of a brick-work chamber divided by interior walls of brick. The two outer chambers are filled with bricks piled in loosely, chequerwise, so as to present a large surface.

We will now suppose a cylinder to be started, and describe the operations. A gas producer being in working order and delivering its gas at a regular rate, it is lighted and the flame passes through

the cylinder, which in the course of a few hours attains a white heat. The waste heat from the revolver has also passed through and heated the right hand division of the regenerator to a bright cherry-red. A shunt valve is now opened, causing the waste gases to pass through the left-hand regenerator, while the gas from the producer is caused to flow through the heated right-hand chamber, and thus arrives at the mouth of the revolver already intensely heated. The result of this is that an immediate economy of fuel is produced, and to avoid overheat it will be necessary to reduce the gas supply. During the whole operation the air necessary for combustion is also heated by passing down a separate division of the regenerator, where it receives heat from the walls of the outer compartments. As soon as the right-hand chamber begins to cool, the furnaceman reverses his shunt valve and the fresh gas is turned through the hot regenerator, while the waste combustion products are heating that which has cooled down. The effect of this method of working is thus to return into the furnace the heat which, in ordinary methods of work, goes up the chimney. No startling innovation occurs save in the application of the method to cement making. Regenerative furnaces are in use all over the world, and an intelligent furnaceman will learn how to manage one in a few hours.

We have now to turn our attention to the cement which, taken from the drying floor, we described as crushed to a coarse powder. The powder is lifted by any convenient mechanical arrangement, to a hopper, placed at the upper end of the revolver; from this it falls in a steady shower *through the flame*, to the lower side of the cylinder, and lodges between the feathers. As the advancing side of the revolver rises, it is lifted until the feather attains such an inclination as to shoot it off again through the flame to the bottom once more, but, owing to the incline, several inches nearer to the lower end. As the revolver moves on, this operation continues again and again, the powder is constantly lifted and shot through the flame in showers, gradually getting nearer and nearer to the lower and hotter end of the cylinder, until at last it falls out into a receptacle at the lower end. In practice, it is found desirable to rotate the cylinder at such a rate that any given particle of cement takes about thirty minutes to travel from one end to the other, during which time it has been lifted and shot through the flame about fifty times.

The powder has now arrived at the outside of the furnace, and having been delivered on to a floor to cool, is at once ready for grinding; that is, it is in the same state as the clinker after being seven days in the kiln. Unlike cement clinker, however, it does not consist of lumps weighing from fourteen pounds downward, and as hard as granite, but of a coarse, roughly-agglutinated sand. Nor does it consist of an over-burnt skin, a properly-burnt inner portion, and a possibly under-burnt inmost part, but if the operation has been properly carried out, each fragment has been heated to exactly the proper degree. How exactly this heat can be regulated is well known to all who have ever used a regenerative furnace. Again, the fuel used is gaseous, consequently no mixture of coke ash has taken place, and the cement is really and in fact what it professes to be.

So much would have been achieved had the new process been introduced with a furnace which had to be cooled in order to remove its contents, but—and here comes in a source of immense saving, not only in fuel, but in repairs—this is not an intermittent but a continuous one. The revolver once started, goes on night and day delivering its hourly quantity of properly-burnt cement until its fire-brick lining requires renewing, an operation that only has to be performed occasionally. There is no constant loss of time and heat during cooling, loading and unloading, as with the kiln, but the hourly delivery of a ton of cement enables a works with two cylinders to turn out 336 tons of cement per week, a quantity that eleven kilns of the usual capacity could not produce in the same time. As a matter of prudent practice, the inventor advises that a spare cylinder with its regenerators should always be ready, so that a works using two cylinders would, as a fact, have three. In such a works, as soon as a revolver was seen to be in such a state as to require attention to its lining, gas would be turned on to the standing furnace, and in a few hours it could take up its duty, allowing the shut-down revolver to be repaired without any stoppage or diminution of the output. It is needless to say that the relining of a kiln is a very different matter, involving the loss of its services for many days.

(*To be continued.*)

THE JULIEN SYSTEM OF ELECTRICAL TRANSMISSION.

BY PEDRO G. SALOM, of Philadelphia.

[*A Paper read at the Stated Meeting of the* FRANKLIN INSTITUTE, *February 16, 1887.*]

Jos. M. WILSON, President, in the Chair.

MR. SALOM.—I take great pleasure in bringing to your attention this evening, what Dr. Wahl has been pleased so happily to term "The Julien System of Electrical Transmission." I feel somewhat diffident in presenting this subject as I am not an electrician. But electricity is approaching so close to the domain of chemistry, that the border line is becoming more and more indistinct, and it is a question now, whether electricity will absorb chemistry or chemistry devour electricity. This, then, must be taken as my excuse. But I am here to-night not so much to expatiate on the electric qualities and attributes of storage batteries, as to inform you that a new field of industrial development in the mechanic arts has been opened. A field that will give employment to thousands of men and women and, therefore, it has a high industrial as well as scientific value. In taking up the theoretical aspect of the case, I would state that I believe a conscientious study of the galvanic battery, and more particularly the storage battery, will help us materially in forming a correct scientific conception of the nature of electricity. We are in the same relative position to-night in regard to electricity that our forefathers were 100 years ago in regard to heat. Not quite so bad, perhaps, for while we are willing to admit that we know nothing about electricity, they thought they knew a good deal about heat.

It was not until Lavoisier's time that a true conception (on a chemical basis) of the phenomena of heat was found, and it is to chemistry again that we must look for a true explanation of the phenomena of electricity.

As it is a fundamental maxim that we can create neither matter nor force, and as heat is the sensible result of chemical union or combination, where does this energy come from? manifestly from the atoms taking part in the reaction.

May not electricity, under certain conditions, be the result of chemical disunion, decomposition or molecular transposition. Of course, we understand that an amount of energy must be absorbed by chemical decomposition equivalent to that developed by chemical combination. But in the galvanic battery, there is a double action of combination and decomposition, in which the energy does not appear and disappear as heat, but under such conditions manifests itself as an electrical current. In other words, *electricity is the mechanical expression of chemical affinity, or the force of chemical attraction.* I mean by that, that the mysterious force that holds an atom of H to an atom of O will, when those two atoms are separated under certain conditions, manifest itself in the form of an electric current, and that the amount of current developed will be directly proportional to the number of atoms involved in the reaction and the intensity of the current, or E. M. F., to the chemical affinity they may have for each other. If such an explanation is correct, it accounts for the lack of progress Mr. Edison has made in the great problem of converting the latent energy in coal into electricity directly without the intermediate stage of steam. Such an explanation might account for the dual nature of electricity, since two different elements must always be concerned in its production. And electricity, derived from the dynamo, might be compared to heat developed by friction.

That this idea of the chemical basis of electricity, if I may be permitted to so term it, is becoming more and more general, is evidenced by the works of Favre and Silbermann, Andrews, Thomson, Bertholet and others, and Mr. John T. Sprague, in his great work on *Electricity*, has done for it what Joule did for heat. The mechanical equivalent of electricity is now as well-known as that of heat, and the day is not far distant when we will have with the table of atomic weights a table of atomic energies, and we can then deal with the mechanical equivalent of energy of a chemical reaction, as we now do with the masses of matter taking part in it.

But to return to our subject.

The Julien Electric Company has been organized for the introduction and sale of storage batteries and systems of electric traction of E. Julien, who, in these departments of electricity, has attained a high degree of perfection. Their successful use at Antwerp, Brussels, Hamburg, and Paris, have warranted their introduction

here. Electricity, like water and gas, ought to be stored, the better to admit of its use at all times and as it may be required. Indeed, it is owing to the want of a proper method of storage that it is not in more general use.

The importance of having a practically, indestructible, secondary battery cannot be overestimated. The flexibility of electricity, so to speak, the infinite variety of purposes for which it can be employed, render a safe, cheap, and simple mode of application—a desideratum of the highest importance. These three elements are united in a storage battery.

History.—The reverse current arising from plates of the same metal, which had been used in a voltameter, was first observed by a French chemist, named Gautherot, in 1801. It was at first thought that the plates received a charge of electricity, and that the secondary pile was, in fact, analogous to a condenser. But the chemists soon demolished this idea, and showed that the return current and counter E. M. F. were not due to a storage of electricity, but to the chemical affinities of substances produced by the previous decomposition. In 1859, Gaston Planté, who made the most exhaustive researches in secondary batteries, constructed a secondary pile, which is really the parent of all modern accumulators. A number of attempts have been made since that time to store the electric energy of a dynamo, the most notable of which are those of Messrs. Houston & Thomson, in 1879, who proposed to use a gravity form of the Daniell cell. Mr. Brush, of electric light fame, and M. Faure.

Under the action of a primary current, the storage battery becomes a reservoir of dynamic energy, which it returns at will, in the form of heat, light, power, etc.

All lead-plate batteries are founded on the principle of Planté's invention, an electrode, consisting of a conducting support with active material. But on account of this very principle, based as it is upon the oxidation of the support plates (which oxidation cannot be arrested), the plates rapidly deteriorate, and are therefore of very little industrial value. Notwithstanding the improvements made upon Planté's secondary pile during the last five or six years, by a large number of electricians, Faure, Brush, etc., the storage battery (which made no little noise at the time the electric light-

ing began to take on the development it has since acquired), did not respond to the public expectation then created, and soon fell into what may very appropriately be called a state of "innocuous desuetude." This condition of things was brought about by the well recognized defects of those batteries—low efficiency—irregular discharge—rapid deterioration—exorbitant cost of maintenance, etc. These are all defects resulting from the application of a principle which has for its basis, as well as consequence, the peroxidation of the positive support plates, whether the active matter on the plates be obtained by disintegration or addition. It remained for Edmund Julien, a Belgian engineer, who first introduced the Faure battery into notice, and who better than any other person became acquainted with its defects, to solve this important difficulty by adopting a principle diametrically opposite to the one employed by his predecessor. His batteries are made according to a new process, that of an *inoxidizable* support plate. They are absolutely exempt from the defects inherent in all other secondary batteries, and so have the industrial advantages which are wanting in all others. It is largely owing to the wide-spread attention which Mr. Julien's invention has attracted, that storage batteries have re-entered the domain of electrical industry, and a new industry of gigantic magnitude will undoubtedly be added to our other resources. In support of this statement, we cite the following facts:

(I.) It is by subjecting his invention to public tests and inspection that Mr. Julien has re-conquered the ground that had been lost. In 1885, on the occasion of the general Exposition at Antwerp, the Belgian government invited the various nations to a trial of the different systems of street-car traction. The contest was begun on the first of May, and lasted until October 31st. "L'Electrique," a Brussels company, organized for the purpose of exploiting Mr. Julien's system abroad, took part in that exhibition, with an electric street car, whose motor was driven by storage batteries. This car, which was operated side by side with cars propelled by steam and compressed air, took first prize and the DIPLOMA OF HONOR, at the same time the jury awarded Mr. Julien a second diploma of honor for his batteries. These were the highest distinctions awarded at the exhibition. The jury which awarded these diplomas consisted of ten members, appointed by the governments

of France, England, Germany and Belgium. In reporting on Mr. Julien's car, they speak as follows:

"The electric street car very regularly performed the ordinary service with one or two cars, and the extra service, also with one or two cars, which was imposed on it.

"The two batteries of accumulators, which were employed, and which seemed to have been *in use previous to the opening of the exhibition, showed no change* when they were withdrawn from service. The metal of the support plates was found to be *absolutely sound*, and the active matter adherent throughout; no plate showed any tendency to buckling or deterioration; this result is to be attributed to the *special composition* of the support plates made by 'L'Electrique.' There was an entire absence of polarization. The treatment of the batteries was confined to the replacing of acidulated water lost by evaporation, and during the charging. The battery weighed less than a ton, including boxes and liquid."

Those acquainted with the work required of a battery employed for traction, and which is peculiarly trying by reason of the heavy currents exacted from plates of the lightest admissible weight, and of the constant shaking of the car, will comprehend the importance of a report like the one above given. An account of the daily work done by the car may be found in the table annexed to the report of the jury. This table shows that the batteries furnished the necessary current during fifteen hours to propel the electric car, drawing another ordinary street car, both heavily laden with passengers, over a course of fifty-nine miles a day.

(II.) In his work on *Electro-Technology*, Prof. Eric Gerard, of the University of Liège, says: "In all storage batteries it has been found necessary to replace the positive electrodes after a certain duration of service, for the reason that the lead becomes transformed into peroxide, and the plates fall to pieces. Mr. Julien, of Brussels, has succeeded in prolonging the life of these electrodes by employing for their support a metallic compound, which prevents their oxidation and buckling."

The author then gives the result of trials made at the University of Liège, in 1885, with a battery of twenty-four elements of the Julien system. This trial was made under the supervision of the International Commission, charged with testing the products exhibited at the Antwerp Exhibition.

The following are the results, already published in the *Electrical World*, of New York, of November 20, 1886.

Duration of charge,	7 hours, 33 minutes.
E. M. F. per cell,	2·35 volts.
Average strength of current per kilogramme,	1·86 ampères.
Energy absorbed per kilogramme,	10,700 kilogrammetres.
Ampère hours per kilogramme,	14.
Duration of discharge,	6·48 minutes.
Final E. M. F. per cell,	1·89 volts.
Average strength of discharge per kilogramme,	1·74 ampères.
Energy given out per kilogramme,	8,600 kilogrammetres.
Ampère hours per kilogramme,	11·83.
Commercial efficiency,	80 per cent.

On the subject of the capacity of the accumulators and their efficiency, Mr. Gerard states that to store one electrical horse-power hour (270,000 kilogrammetres), it requires 180 kilogrammes of Planté's accumulators; sixty kilogrammes of Faure accumulators, with an efficiency of only fifty per cent., according to experiments made at the "Conservatoire des Arts et Metiers," in Paris.

According to the above results, $\frac{270,000}{10,700}$, or twenty-five kilogrammes of Mr. Julien's accumulators, will give one electric horse-power hour with an efficiency of eighty per cent.

(III.) The diagram (exhibited) of discharge of a Julien battery, composed of twenty-nine elements of forty kilogrammes each, used by the Edison Company, in Paris, shows the efficiency and the regularity of action of the same, charged at a rate of fifteen ampére hours per kilogramme and discharged at a rate of thirteen and one-half ampéres with an efficiency in ampéres of ninety per cent. It will be perceived that the electro-motive force of the battery was two volts, after twenty-two hours of continual discharge.

(IV.) As an additional proof, we would state that Mr. Huber, engineer, who exploits the Julien system (accumulators and electric traction), in Hamburg, has run electric cars in regular daily service of sixty-nine kilometres in the streets of that city, since May, 1886, with a success that all scientific papers abroad are pleased to acknowledge. The same set of batteries has been employed from the beginning without any change or deterioration whatsoever.

(V.) And finally, Mr. Julien has lately been the recipient of new

distinctions in addition to those already obtained by him for his batteries.

On the occasion of the International Exhibition of Arts and Sciences in Paris, which began on June 21, 1886, Mr. Julien decided to renew, on the large thoroughfares of that capital, the official demonstrations made by him at Antwerp. Two of his cars conveyed passengers from the Place de la Concorde to the Palais de l'Industrie during the exhibition.

The jury, presided over by M. Fontaine, President of the International Society of Electricians of France, and composed of ten eminent members of that society, awarded Mr. Julien the FIRST PRIZE and DIPLOMA OF HONOR, for his accumulators and with an equal distinction for his system of electric traction.

His competitors, who exhibited the Planté and Faure types of accumulators, only obtained third-class prizes.

The confirmation of the decision of the Antwerp jury by the Paris jury is of manifest importance.

(VI.) I purposely abstain from citing other than those which, like the preceding, are publicly known and supported by official proof. These facts are sufficient to establish, beyond question, the superiority of the accumulators of this company.

By way of comparison between the Julien and other well recognized secondary batteries—those of Faure, for example—let us turn to a pamphlet, recently issued by the Electrical Accumulator Company (by some called the Vail Company), in which we find the following data in relation to their accumulators:

For a cell weighing 125 pounds, E. M. F., . . .	2 volts.
Intensity of current, ...	35 ampères.
Capacity, ...	350 ampère-hours.

or, a current of $\frac{28}{100}$ ampère and a capacity of $2\frac{8}{10}$ ampère-hours per pound.

It is fair to assume that this is the very best that that battery will do. We have no proof, other than the company's own statement, that it will even do that.

Now, putting these figures side by side with those of the Julien accumulator, given above, and as the result of public and official tests, we find:

	INTENSITY OF CURRENT PER POUND—	
	Faure.	*Julien.*
Ampères per pound, ...	0·28	0·86
Capacity per pound in ampère-hours, ...	2·8	5·38

Thus, the capacity per pound of the Julien accumulator is about *twice as great* as that of the Electrical Accumulator Company's, while the current is *three times more intense*, and with a *greater E. M. F.*

The Brush Company claim only an E. M. F. of 1·82 volts.

These comparisons must not be regarded in the light of criticism. They are introduced solely to show the superiority of the principle of construction of the accumulators of this company, viz: an inoxidizable support plate.

The accumulators of this company may be employed for the following purposes:

The electric traction of all vehicles, more especially street cars.

The utilization of natural forces, such as water-falls and streams.

Domestic lighting.

Running motors of every kind.

Lighting of railroad cars and of street cars.

Aërial navigation.

Medical uses, etc.

I would call attention to the fact that the batteries in use here this evening have been made in this country by men who, six months ago, had never seen or heard of a secondary battery.

They have been brought from our factory in Camden already charged, in trays similar to those used in our system of lighting railway cars. The four trays, containing twelve cells each, will run twenty sixteen-candle-power lamps for eight hours, and you will observe that the lecture-room has been brilliantly illuminated during the evening (three hours) by eighteen sixteen-candle-power lamps and two 150-candle-power lamps, without the slightest diminution in quality or steadiness of the light. The latent energy these forty-eight batteries possess is equal to about 50,000,000 foot-pounds.

BOOK NOTICES.

PETROLEUM, ITS PRODUCTION AND USE. By Boverton Redwood, F.C.S. *Van Nostrand's Science Series, No. 92.* New York, 1887.

Van Nostrand has republished, in convenient 18mo form, as one of his Science Series, an abridgment of the lectures on this subject, delivered last year before the Society of Arts, London, by Boverton Redwood, chemist to the London Petroleum Association.

While the little manual so produced does not cover the wide range of petroleum interests as fully as *Crew's Treatise on Petroleum*, just issued, it gives a correct and very readable account of the occurrence of both American and Russian petroleum, both of which fields have been personally visited by the author. It also gives a very clear presentation of the chemical composition of petroleum, and the products obtained by its distillation. The methods of pipe-line transportation in this country, and of steamer transportation on the Black Sea and the Volga, are also very fully described. Of special value the description are of the several forms of testing apparatus, both open and closed cup, for determing flash and fire test. The construction and method of operating the Abel apparatus, which is the one officially used in both England and Germany, are quite fully treated of.

Quite a section is devoted to a discussion of petroleum lamps, and the relative advantages of different forms of wicks, both flat and round. The comparative merits of American and Russian refined oils, in respect to illuminating value, are also fully stated.

Indeed, both the chemist and the oil dealer, or expert, will find very much of value, while for the general reader the whole subject is stated in a thoroughly interesting way. We can commend it as one of the very best of manuals on petroleum and mineral oils. S. P. S.

ANNUAL REPORT OF THE DIRECTOR OF THE DRAWING SCHOOL OF THE FRANKLIN INSTITUTE, FOR THE SESSIONS 1886–87.

THE increased attendance during the year, and the earnest purpose shown by most of the students, are gratifying signs of a public appreciation of the importance of a knowledge of drawing, and also of the efficiency and standing of this school. Machinists, pattern-makers and skilled men connected with engineering trades, are alive to the fact that a thorough knowledge of constructive drawing is essential to their success; but carpenters, masons, plumbers and those connected with the building trades, seem content, as a rule, to blunder along in their rule-of-thumb fashion, cutting, trying, altering and patching, until finally an approximation to a design has to be accepted from sheer necessity. It is to be hoped that the facilities offered to the rising generation to obtain a knowledge of exact methods of laying out work beforehand, will

soon have its effect in improving this state of affairs. Continued effort should be made to educate everyone connected with the various constructive trades up to a realization of the importance of training the imagination and reasoning power, in order to acquire the ability to provide for the harmonious arrangement of all the details of construction, so as to avoid the absurd blunders which are continually occurring and to secure united effort, where one set of mechanics will not disfigure work already done, nor interfere with work to be subsequently done. Let any intelligent person watch carefully the building of a house, for instance, and it will be safe to predict that his admiration of the intelligence of our skilled mechanics will not be greatly exalted. Walls are built up solid and then holes are knocked in them for drain pipes, gas pipes, water pipes, cold-air flues, etc.; joists are laid and then cut to allow passage of hot-air pipes; gas and water pipes are laid without any regard to their interference with other details, or to facility of reaching them for repairs, and, if the outlets are located within a foot of their designated places, it is cause for great rejoicing; and if some are not occasionally covered up by the plasterer and lost, it is because there is a watchful eye around; soil and ventilating pipes are run through the roof after it is slated; closets and niches carefully designed, of specific sizes for special purposes, vary sufficient to ruin the intention, and so on, *ad infinitum*. This condition of affairs is probably responsible for the superficial character and lack of proper detail and definite dimensions in the working drawings of many of our architects who have, doubtless, been so completely disheartened by their experience of the manner in which the constructive features of their plans have been carried out, that they have finally adopted the system of merely suggesting, in a general way, by means of their drawings, and trusting to providence and the builder for the result. The only remedy for all this is the better education of our skilled mechanics, and a very important part of this education should be constructive drawing; for, setting aside the utility of the art itself, its study tends to develop the very qualities that are now lacking, and to prove the ease and accuracy with which the unity of a design and the proper arrangement of all its details can be fully laid down beforehand.

As regards the decorative and artistic branches of drawing, little need be said, as interest in them has been fully awakened, and the good effect of the fostering care which they have received, is shown in the marked improvement in design, displayed of late, in furniture, wall paper, carpets, china, and all our material surroundings. Manufacturers have found that ugly, ungraceful objects will not attract purchasers except at low prices, while artistic effect and handsome decoration command their own reward.

This school has received several improvements this season, the most important of which has been the introduction of incandescent electric lights in the class rooms, adding much to their comfort and healthfulness, and permitting the use of color correctly. As a consequence, some good work has been done in oil painting from still-life, in addition to the studies from casts, in black and white, to which, being an evening school, it has been necessarily confined heretofore. The classes in mechanical or constructive drawing have well maintained their high standard, and the architectural class is

becoming a very important feature. The general system and methods are being steadily improved, and the efficiency of the school increased. Eight separate classes have been taught throughout the season.

The following students are entitled to HONORABLE MENTION:

IN THE SENIOR MECHANICAL CLASS.

T. Edward Schiedt, George J. Henninger,
Robert D. Milner, A. E. Atkinson,
Edward Hein.

IN THE INTERMEDIATE MECHANICAL CLASSES.

George S. Cullen, George F. Johnson, M.D.
G. W. Blackburn, George W. Haldeman,
George W. Irons, Horace E. Jones.

IN THE JUNIOR MECHANICAL CLASSES.

E. W. Davis, Wm. J. Lawrence,
C. P. Barnett, Maurice Patterson,
George R. Moore, Jr., Wm. Bartholomew, Jr.

IN THE ARCHITECTURAL CLASS.

Horace T. Hatton, Walter L. Allen,
Gilbert B. Downes, Stanley Bevan,
William Wrifford.

IN THE FREE-HAND CLASS.

M. Stratton, Jr., Joseph B. Carney,
Arthur Taylor, Wm. H. C. Swain.

IN THE OIL-PAINTING CLASS.

Eugene Dillon, Mary H. Goudkop.

The following students are awarded SCHOLARSHIPS from the B. H. BARTOL fund, entitling them to tickets for the next term, beginning SEPTEMBER 27th:

Vincent A. Clarke, Senior Mechanical Class,
David Uhle, Intermediate Mechanical Class.
Juan S. Kutz, Junior Mechanical Class.
Henry J. Parrott, Architectural Class.
Edward Winkens, Free-Hand Class.
Edwin S. Sutch, Jr., Oil Painting Class.

The following students having attended a full course of four terms, with satisfactory results, are awarded certificates to that effect:

T. Edward Schiedt, Henry J. Parrott,
Robert D. Milner, Horace T. Hatton,
Charles Eggert, William Wrifford,
George A. Baré, Walter L. Allen,
Edward A. Muir, Thomas Stephen,

William E. Mullen,	Edward Winkens,
Edward Hein,	Joseph B. Carney,
Edward B. Seiberlick,	Wm. H. C. Swain,
Mary H. Goudkop,	Eugene Dillon.

In conclusion, it may be stated that no pains will be spared to promote the continued improvement of the FRANKLIN INSTITUTE Drawing School.

WILLIAM H. THORNE, *Director.*

Franklin Institute.

[*Proceedings of the Stated Meeting, held Wednesday, May 18, 1887.*]

HALL OF THE INSTITUTE, May 18, 1887.

MR. JOSEPH M. WILSON, President, in the Chair.

Present, eighty-seven members and six visitors.

New members added since last meeting, eleven.

The Special Committee appointed to investigate the protest of POUL LA COUR, of Copenhagen, against the award of the Elliot Cresson Medal to PATRICK B. DELANY, of New York, for his System of Synchronous Multiplex Telegraphy, presented a report, which was adopted and referred to the Committee on Publications. The committee's conclusion was, that it found no good reason for revoking the award of the medal which had been granted by the INSTITUTE to MR. DELANY. The committee was discharged from further consideration of the subject.

The Secretary, on behalf of the Special Committee on the establishment of a "State Weather Service," made an oral report, announcing the fact that the bill promoted by the committee, in the Legislature, had passed finally, and had received the Governor's signature. The Special Committee was continued.

Mr. R. MEADE BACHE, of Philadelphia, read the paper of the evening, descriptive of his invention of a "Safety-Stove for Railway Cars."

The Secretary's Report embraced a detailed comparison of the British and American iron and steel trades.

Adjourned.

WM. H. WAHL, *Secretary.*

CORRESPONDENCE.

Is ELECTRICITY FORCE or MATTER?

Editors of THE FRANKLIN INSTITUTE JOURNAL:

Dear Sirs:—During the past few years, I have advanced the following argument to a number of electricians, and, having failed to find anyone who can adduce any good argument against it, I thought it might be of sufficient interest to be discussed in your journal. Possibly it may not be new, but I have never seen it published elsewhere.

I believe it is conceded that everything in the universe is either force or matter; therefore, electricity must be one or the other. If it is matter, it must remain the same in amount, and can never be consumed or generated. If it is force, it may be generated by the expenditure of another force—as that in the energy of a steam engine—and will then *grow less in amount* as it is again converted into other forces—as in the energy of motors, lamps, or in heating wires. Now, it is a well-known fact that quantity of electricity measured in coulombs, never is generated, never is consumed, and never does grow less in the circuit, barring leakage. The current flowing out of a lamp is exactly the same in quantity as that flowing into it, the same being true of motors and of generators, showing that electricity itself is neither consumed while doing work, nor is it generated; after doing work in a lamp or motor, it comes out in precisely the same quantity as it entered. Connect only one pole of a battery to a circuit and there will be no current. Why? The battery is not able to *generate* quantity, or coulombs, of electricity; all it is able to do is to take the quantity which flows in at the negative pole and to send it out at the positive pole, with an increased *pressure* or electro-motive force. The battery, therefore, does not generate electricity, but merely raises the pressure of that which flows in. Electricity, therefore, appears to be matter, but not force. It is precisely analogous to water in a water circuit. The water is neither consumed nor generated. The pump merely increases the pressure of the water which flows in at one end; the water motor or turbine consumes this pressure again, converting it into mechanical work of another kind; it does not consume the water. The quantity of water measured in units of quantity, is the same in all parts of the same closed circuit of water, just as the quantity of electricity in an electric circuit. The work which an electric current can do is due to the pressure or electro-motive force; without pressure it can do no work. The electricity in the earth is like the water in the ocean—neither can do work unless raised to some pressure or height, or allowed to fall below its normal level.

The term force is used here as distinguished from energy, as the latter term might be construed to include in it the conception of matter. But even if matter and energy constitute the universe, the above argument applies equally well. It is understood, of course, that by the term *electricity* as measured in coulombs, is not meant *electrical energy* as expressed in watts or joules, for it is beyond question that the latter is energy.

Perhaps it will be found, at some future time, as has been already suggested, that electricity is the ether (which is believed to be matter) whose wave motions are light, and which, in some other form of motion, is an electric current. Perhaps a current of electricity is the bodily conveyance of ether, as distinguished from a wave motion, which is energy in the form of light. In that case, I would suggest that perhaps the relative motion of the ether of space, and the revolving earth may explain the cause of the earth's magnetism, the ether in motion around the earth (relatively) being an electric current producing magnetic effects. The magnetic polarity and direction at the equator are in accordance with such a theory, and the fact that the lines of force bend down into the earth at the magnetic poles may be explained by the well-known fact that lines of force are continuous circuits; they must return somewhere, and they select the axis of the earth, as there is no motion there to develop a counter-magnetism. They cannot return outside of the earth, as lines of force cannot intersect each other, and, in order to return outside of the earth, they would have to intersect. Furthermore, observations show that they do not return outside of the earth.

The only plausible arguments which I can find against the theory that electricity is matter, are that it may be a combination of force and matter, as, for instance, a wave motion; or, it may be, that the real current is in the *same* direction in both wires leading from a machine, therefore emanating from the machine, and, consequently, being force or energy.

Yours very truly, CARL HERING.

Philadelphia, April 18, 1887.

SCIENTIFIC NOTES AND COMMENTS.

ASTRONOMY AND PHYSICS.

THE OBSERVATORY OF MEUDON.—M. Janssen (*Comptes Rendus*, **104**, 1,067), as President of the Academy of Sciences at its meeting, April 18th, gave cordial welcome to the members of the International Conference of celestial photography, and in so doing invited attention to the observatory at Meudon. Regarded as a "vote of confidence" for the new astronomy, the extraordinary equipments now being put up at this observatory are in the highest degree expressive. As is well known, the instruments for the photographic study of the sun here long in use, have been specially adapted to the work, and by the ingenious methods of M. Janssen, have added not a little to our knowledge.

But now colossal additions are to be made. A reflector of 1 metre in diameter and of only about 3 metres focal length, and consequently giving abundant light to images of sensible size, is provided for the optical, spectroscopic or photographic study of faint nebulæ, comets, etc. The mirror, already completed by the MM. Henry, is considered of rare perfection.

As equatorial, the observatory is to have a huge twin instrument, one refractor of $0^m{\cdot}81$ (32 in.) aperture, to be devoted to spectroscopy and the ordinary

work of astronomy, the other of $0^m \cdot 62$ (25 in.) aperture, intended for photography; the former to serve as a finder while an exposure is made in the latter. The optical portion of the instrument is the work of MM. Henry, the mechanical of M. Gautier. One can appreciate the interest an instrument like this, with a photographic refractor of from 53 to 56 feet focal length, will possess for photography of the moon, double stars and clusters.

But a special interest attaches to this observatory on account of the appliances provided for the study of gases and vapors under great pressures. The laboratory, 350 feet in length, is provided with a series of tubes capable of sustaining high pressures, also with the optical appliances necessary for the study of absorption spectra. M. Janssen mentions one isolated result of work in this direction, to show the interest that attaches to such researches for astronomy.

The study of oxygen shows two orders of phenomena of absorption, the second system consisting of dark bands which are developed according to the square of the density of the gas. An important consequence of this law, of the square of the density then is that, a nebula of a diameter of ten times that of the earth's orbit, and containing oxygen at a low density, might be traversed by rays of light, without presenting the bands of this gas, and that consequently we should be very reserved in concluding the absence of a gas or vapor from a celestial body from the appearances alone of its spectrum. M. B. S.

Recognition of American Astronomy.—Mr. J. W. L. Glashier's address (*M. N. R. A. S.*, **47**, 203), on presenting the Gold Medal of the Royal Astronomical Society, reminds us that this is the second successive year in which an American astronomer has shared the honor of receiving this medal. Last year, it was awarded conjointly to Prof. Edward C. Pickering, Director of the Harvard College Observatory, U. S., and the Rev. Charles Pritchard, D.D., Savilian Professor of Astronomy in the University of Oxford, for their "Photometric Researches." Unaware of Prof. Pickering's comprehensive plan, Mr. Pritchard had also taken up the subject on a large and successful scale, and hence the joint medal, upon the award of which the President took occasion to designate Prof. Pickering's photometry as a "magnificent contribution to stellar astronomy, with which his name will in future be honorably associated."

This year, Mr. George William Hill, of the *Nautical Almanac* office, at Washington, receives the Gold Medal of the Society for his researches upon the Lunar Theory. On account not only of the astronomical, but also of the distinctive and elegant analytical methods employed. Mr. Glashier is justified in giving the unusually detailed review in his President's address, and which consequently becomes an interesting *résumé* of the present condition of the theory. Among the numerous and important additional investigations of Mr. Hill mentioned, are those on the motions of Jupiter and Saturn, upon which he has already been engaged for nine years, and which will probably require three or four years more for their completion. These investigations will displace those of Leverier, which now, in the case of Saturn, fail to represent adequately the observations, and, to use the words of Mr. Glashier, will

constitute "the largest and most complete investigation of the kind that has yet been performed on the American Continent." M. B. S.

PHOTOGRAPHIC SEARCH FOR A MINOR PLANET.—Mr. Isaac Roberts (*M. N. R. A. S.* **47,** 265,) communicates an account of the successful photography of the minor planet Sappho. Scarcely any observations of this planet had been published since 1872, and hence Mr. Bryant, who is engaged in determining its orbit, appealed to Mr. Roberts to find the planet if possible by photography. The planet is, however, not only of the eleventh magnitude in brightness, but its motion in an hour is equal to about 4·2 times its photographic diameter, and thus the trail left not exceeding in density that of a thirteenth magnitude star. With an exposure of one hour on December 30th, the trail of the planet was distinctly recognized and the error of the ephemeris deduced from the photographs is in close agreement with several meridian observations made about the same time at Duerecht.

This is probably the first instance in which photography has been successfully applied for this purpose. It is a distinct demonstration that asteroids of the eleventh magnitude leave strong trails on the photographic plates, and indicates that under favorable conditions those down to the thirteenth or fourteenth magnitudes may be photographed. Another inference suggested by Mr. Roberts is that one astronomer could, in about three years' time, photographically discover all the asteroids existing down to the fourteenth magnitude. M. B. S.

SOLAR STATISTICS AND TERRESTRIAL MAGNETISM.—R. Wolf, (*Astron. Nach.*, **116**, 259), of Zürich, in tabulating side by side the relative number of sun spots, r, and the variation of the magnetic declination at Milan, v, for each month of the year 1886, shows that both were decidedly less than in the previous year. He finds the mean value for r 25·7, for v, 6′·75, and inserting this value for r in the formula derived by him some years ago for Milan:

$$v = 5'.62 + 0'.045 . r$$

the resulting value for v is 6′·79. This value differing but $\frac{7}{100}$ from the observed value again confirms the remarkable relation between the two phenomena—a relation which the Zürich astronomer was, we believe, the first to announce. M. B. S.

NEW DOUBLE STARS.—Prof. G. W. Hough (*Astron. Nach.*, **116,** 274), publishes a catalogue of 209 new double stars discovered by him with the eighteen and one-half inch refractor of the Dearborn Observatory at Chicago. Only thirty-nine of these have a distance of more than 5″, and these with few exceptions are excessively unequal in magnitude; seventy-seven have a distance of 2″ to 5″; forty-three, 1″ to 2″; twenty-five, 0″·5 to 1″, and twenty-five, 0″·5 and less. These double stars are for the most part difficult objects even with the Chicago telescope, and it is certainly creditable to have discovered so many new objects of interest in a field already well explored.

M. B. S.

A NEW UNIT FOR ABSOLUTE TIME.—Mr. Lippman (*Comptes Rendus*, **104,** 1,070) proposes a unit of absolutely invariable time, which, as independent of every astronomical hypothesis, would serve as a check on the

universally adopted unit, the second. The proposed unit of time is the specific resistance of mercury in absolute electro-static units. The constancy of this resistance, the fact that it is indifferent what units of length and mass are used, and the high degree of accuracy that the available experimental methods for its determination promise, are cited in its favor in detail.

M. B. S.

ELECTRICAL INSULATION.—The importance which insulation of wires carrying electrical currents of high potential or great intensity, has acquired, is evidenced by the appointment of a Scientific Commission, composed of Profs. Houston and Marks and Messrs. Hering and Garver, by the National Electric Light Association. The duty imposed upon this commission is to formulate rules and regulations for the proper installation of plants for electric lighting, to investigate the various forms of insulation now commercially used, and to report at the next meeting of the National Association.

This Commission is also directed to meet and confer with a committee appointed by the Electric Club, of New York, and also with a committee of underwriters, with a view to formulating and agreeing upon rules which will be satisfactory to insurance companies.

Fire-proof insulation, which will not take fire from a wire overheated by too intense a current, is, in most instances, not water-proof; and water-proof wire, which will prevent leakage and short circuiting by means of water or moistened wood is, in turn, not fire-proof.

Paraffine insulation takes fire, and carries the flame, like a taper, along the whole length of the wire; it may, however, be regarded as water-proof under ordinary conditions. India-rubber is better, but will burn. The "Underwriters'" insulation will not burn readily, but is not water-proof, and, when exposed to the weather, soon hangs in rags from the wires, the cotton-painted covering having rotted away. Perhaps regular repainting might prevent this, but we do not know that any company has tried the experiment.

Insulation in underground conduits has been suggested, and ardently advocated, as a preventive of danger from electricity, but the danger from leaks in high potential circuits would be very much increased, as a person standing upon the ground and touching only one of the wires (he need not complete the metallic circuit) might receive a fatal shock should there be a leak, and, in order to be used, the wires must come out of the ground somewhere.

The alternating currents of high potential, which it is proposed to use in the Gaulard and Gibbs system of converters (induction coils) can give severe shocks when only one of the wires is touched, and should have special care in insulation, and, although the induction coil is a simplified dynamo, in which the lines of force cut the armature wires, instead of the armature wires cutting the lines of force, as with the dynamos. English experience still shows great danger of fire from overheating of the cores of these coils, due to the rapid reversals of polarity when long continued. This should be overcome before their use is permitted in unguarded places.

The public should demand the most unmistakable proof of proper safeguards against loss of life or by fire, from any new scheme of an electrical nature before permitting reckless inventors to experiment at the risk of life and property.

It has been frequently said that electric lighting has been killed in England by too much legislation, as there they do not permit 200 volts to be exceeded inside of buildings. In America we have no such restrictions, and while we have not killed electric lighting by legislating for the safety of the public, we have directly or indirectly killed a great many people by permitting ignorance, recklessness, and cupidity to take risks which are controllable and unnecessary.

At the inquest upon the bodies of John Johnson and John Gibson, killed at the Temple Theatre fire, it was shown as conclusively as circumstantial evidence could prove it, that the origin of the fire was either a short circuit in a flexible leader to one of the incandescent lamps, or by reason of one of the incandescent lamps being so placed as to be enveloped and have its heat confined by a curtain.

It was further discovered that the whole of the wiring which followed that properly done by the Edison Company, was done by one or more employés of the theatre lessees, in the most reckless and dangerous manner. One of these employés at least was permitted to do most of the work without having the least knowledge of electricity or its laws and dangers.

The jury were careful to say in effect that they regarded incandescent electric lighting as the safest form of artificial lighting in existence, but there is no warrant in this statement for taking risks that no one would dream of taking with gas- or oil-lighting.

The recent inquest, during the past week, upon the body of a lineman of the Brush Electric Light Company, developed the fact that his death resulted from an accidental contact with a poorly-insulated wire. It was hardly chargeable to carelessness on the part of the company, perhaps not to carelessness on his part. However, the fact remains, that, had the insulation been good the man might now be alive.

The question arises, What shall we do to protect ourselves? Legislation quite frequently does more harm than good, because it cannot keep pace with the progress of scientific discovery, and places unnecessary limitations upon enterprises worthy of encouragement.

Can we prevent, or, at least control, risks to life and property? The underwriters and the responsible companies engaged in electric lighting are endeavoring to do this by the appointment of commissions composed of men known to be familiar with the laws of electricity, who shall devise means to avoid risks of fire.

Should not our state or our municipal government appoint similar commissions, charged to supervise means to avoid risk to our lives, and demand that all companies shall prove to this commission that they have devised proper safeguards against possible *murder* before permitting them to install their plants?

W. D. M.

CHEMISTRY.

DISTILLATION AND PURIFICATION OF MERCURY. (*Berl. Ber.*, **20**, 497.) It is generally accepted that mercury cannot be fully purified by distillation, and by earlier observations of the author had found that these distillations left crude mercury quite impure. Some experiments have now been made to ascertain whether the foreign metals are vaporized with the mercury, as water vapor carries over other substances, or whether they are carried off mechanically. The mercury was mixed with lead, bismuth, tin, sodium and copper, and then distilled, first from porcelain, afterwards from glass retorts. As long as the metal is very impure, the glass retorts are destroyed, hence the necessity of distilling first in porcelain. After twelve distillations, the retorts contained no residue, and the mercury was perfectly pure, as was proved by dissolving about two grammes in nitric acid, evaporating in a weighed platinum capsule and igniting; the weight of the capsule was unchanged. W. H. G.

PRODUCTION OF A DYE AND TANNING MATERIAL FROM CATECHU. E. Ziegler (*Dingler's Polyt. Journal*, **261**, No. 1). From an abstract in *Journal of Soc. of Dyers and Colorists*, **3**, 48.—The process described by the patentee (German patent, No. 36,472), has for its object the separation of the coloring matter contained in catechu from the tanning agent, and thus rendering possible the separate application of both.

The catechu, which generally comes into the market in bales of fifty to 100 kilos, is first broken into small pieces; a given quantity is then put into a suitable vessel, provided with a stirrer, and from two to three times the weight of cold water is added. The tanning material is dissolved in this—more quickly when stirred. The coloring matter insoluble in water, remains behind as a fine powder. As pieces of leaves, insects, and other impurities, are always found in the bulk, these are next separated by filtering through a sieve.

The coloring matter and the tanning agent are now separated by filtration, or by means of a filter press. The coloring matter which remains on the filter in the form of a powder, may be used at once for dyeing; but it is better to boil it up with a little water, when it dissolves, and then to dry it by heating with steam. A cake is the result.

It is said to be advantageous to add mordants, such as alum or tartar, in given proportions, before steaming. The cake, obtained after steaming and drying, is then powdered, and can be used for dyeing in exactly the same manner as catechu. The new coloring matter is said to yield considerably better than catechu, and to give better and purer shades.

The tanning material is best introduced into commerce after evaporation to the consistency of a syrup. By mixing it with a small percentage of nitric acid, its color is clearer. It forms a very valuable and powerful tanning agent—one part replacing about ten parts of the best oak bark—it acts very quickly, and is applicable for tanning of upper or sole leather, reducing the time of the operation considerably, without damaging the leather.

It is self-evident that in preparing the catechu, on account of the tanning material present, the use of iron apparatus must be avoided. H. T.

DETERMINATION OF PHOSPHORUS IN IRON AND STEEL.—Leopold Schneider (*Dingler's Polyt. Jrl.*, **263**, 383) communicates his results on the analytic determination of phosphorus in iron and steel, and on its state of combination in the latter. The author shows, by a series of analyses made with a metal containing iron = 78·6, phosphorus 14·6, that considerable quantities of the latter may escape detection unless the proper precautions be taken.

Of the above metal he digested one gram with 15 cc. of nitric acid (spec. gr. 1·2) for twenty-four hours on a water-bath, let it evaporate to syrup consistency, and took it up with hydrochloric acid and water. From this solution the iron was removed by $(NH_4)^2S$; it was then evaporated several times with HCl to destroy the nitrates, and PH^3O^4 was precipitated as $(Mg,NH_4)PO^4$. The precipitate corresponded to 13·32 of phosphorus. From the filtrate NH^3 was expelled by boiling, acidulated slightly with HCl and $HgCl^2$ added. After some rest 0·099 gr. Hg_2Cl_2 was precipitated. This was filtered off, and from the filtrate, after removing the mercury by hydrogen sulphide, magnesium solution precipitated 1·23 per cent. of phosphorus, which, added to the amount found first, is equal to 14·55. The author has thus shown that some phosphorus, in pig iron or steel, will only be oxidized to phosphorous acid, by nitric acid, unless the solution be evaporated to *dryness* and then heated until the *ferric nitrate begins to decompose.*

In order to determine the state of combination of phosphorus, the author separated the iron phosphide from different samples of pig iron, by means of an aqueous solution of cupric chloride. This solution dissolves readily the free iron, the carbide, but not the phosphide. The pig iron and the residuum were analyzed separately. Results are in the following table:

	Pig Iron.							Residuum.	
	C	Graphite.	P	Si	Mn	S	Cu	P	Mn
Spiegel iron,	3·3	..	2·5	0·06	0·2	0·04	..	18·6	..
White iron,	..	..	1·45	..	..	..	..	18·6	..
White iron,	3·56	..	0·53	0·07	2·47	0·038	0·03	18·2	..
Gray iron (coarse),	..	2·2	1·48	4·0	..	..	..	18·2	..
Gray iron,	0·55	2·85	0·94	1·8	0·07	0·01	0·01	18·5	..
White spiegel iron,	..	..	2·01	0·46	4·33	..	..	20·5	5·7
White spiegel iron,	3·98	..	3·4	0·89	18·15	..	..	37·7	52·8
Ferro-manganese,	5·28	..	0·38	..	28·7	..	..	38·8	54·4

The most striking feature in this table is the constancy in the phosphorus of the residue in all pig irons free from manganese, no matter how much their carbon and silicon percentages may vary. In all of these the residue corresponds to a ferro-phosphide of the formula Fe_2P. With the manganese the phosphorus in the residue rises rapidly. If the iron percentage be calculated as Fe_2P, then the manganese corresponds to the formula Mn_2P_2. The phosphide was invariably obtained as a pulverulent granular admixture. It is not the cause of the characteristic reflecting surfaces in spiegeleisen, because after a piece of this latter had been kept in dilute HCl for several months, it

could be broken into many delicately-thin leaves, from which concentrated acid extracted all the phosphorus without destroying the shape.

The small quantities of phosphorus contained in wrought iron and steel, exists probably as the same phosphide found in pig iron disseminated in granular particles.

The fact that relatively more manganese is found in the residue than in the original pig iron, tends to demonstrate a stronger affinity of phosphorus for manganese than for iron. G. A. K.

General Methods for the Formation of Crystals by Diffusion. By C. E. Guignet (*Comptes Rendus*, **103**, 873).—The methods described by the author are a development of the researches of Becquerel on the slow reactions of fluids through porous substances. When a solid is introduced into a saturated solution of another solid in a menstruum in which the first is soluble, there is a replacement in the solution, and the substance in solution separates in crystals. Sulphur is thus separated from its saturated solution in carbon disulphide by the introduction of solid paraffin. Also by the gradual dilution of the saturated solution through diffusion, the solid separates in crystals; thus a saturated solution of lead chloride in hydrochloric acid covered with a layer of hydrochloric acid, and this by a layer of water, will deposit fine crystals of lead chloride. The preceding actions are physical, but the method is equally applicable to cases in which double decomposition takes place. Crystals of sodium sulphate, placed in a saturated solution of barium chloride retain their form, but become opaque; when they are broken, each is found to be a mass of small crystals of barium sulphate. If both substances be in solution, one of the liquids is placed in a crystallizing dish, and this is set in another deeper dish containing the other solution, both dishes being filled nearly to the top of the inner one. Both vessels are then carefully filled up with water until communication is established. Sodium sulphate and calcium chloride thus give long crystals of calcium sulphate; sodium sulphate and lead acetate yield crystallized lead sulphate; potassium ferrocyanide and lead acetate give long, pale yellow needles of lead ferrocyanide. W. H. G.

Estimation of Aluminium in Presence of a large Proportion of iron. By R. T. Thomson (*Chem. News*, **54**, 252).—In view of the introduction of the mitis alloys, these methods are of practical interest. The first method is best adapted when there is but little manganese present; if there be much manganese, the second method should be used. (1.) Reduce the iron to the ferrous state by passage of sulphur dioxide, boil off the excess of the latter, and when cold add phosphoric acid or ammonium or sodium phosphate in excess of that required to precipitate the alumina, then ammonia until a permanent cloudiness appears; lastly, an excess of ammonium acetate. If the precipitate contain much iron, it should be washed, again dissolved in hydrochloric acid, reduced by sulphur dioxide and the whole process repeated. (2.) The iron solution is reduced as before, ammonia is added until permanent cloudiness is produced, then excess of ammonium acetate, and boil; if the precipitate contains much iron, the operation must be repeated. In either

case, when a satisfactory precipitate is obtained, it is dissolved in hydrochloric acid, a little nitric acid added, and, after boiling, the liquid is nearly neutralized with sodium hydroxide, and then boiled with a large excess of the latter reagent. The aluminium is then precipitated as phosphate, and the precipitate washed with a one per cent. solution of ammonium nitrate containing about one decigram per litre of mono-ammonium phosphate. It is weighed as $Al^2\ P^2\ O^8$. W. H. G.

SPECTROSCOPICAL TEST OF TAR COLORS.—P. Schoop (*Dingler's Polyt. Journal*, **262**, 424).—Artificial and natural dye stuffs are tested with regard to shade and purity as well as strength, by sample dying, which requires great practice and shows differences in strength of but five per cent. only with difficulty, whilst differences in shade often lead to errors in estimating the strength.

The investigations of H. W. Vogel, K. Vierordt and G. Krüss have rendered it possible to determine, with rapidity and accuracy, the amount of coloring matter in a solution. Their method is based on the following considerations: Every substance can absorb only those rays of light, which have the same rate of vibration as its own molecules, producing, therefore, absorption bands in the spectrum of the light reflected by it. With the same light, the absorption band is the darker the greater the amount of absorbing (colored) substance contained in the unit of space, and there is a simple relation between the absorption of the light and the quantity of coloring matter.

If $\frac{1}{3}$ of the rays of a beam of light pass through a 1 cm. stratum of color solution, a second similar stratum will allow only $\frac{1}{3}$ of this $\frac{1}{3}$ to pass through it, and so on. The same result is obtained if, instead of the light passing through two such strata of solution, it passes through one of double strength. Therefore, if the amount of light which passes through a 1 cm. stratum of a solution, containing 1 mg. of color in 1 l. $= a$, then the amount of light passing through a solution of x-times the concentration of the former is $b = a^x$, where x indicates the number of mg. of coloring matter in 1 l. solution, or $log\ b = x\ log\ a$ or $x = log\ b \div log\ a$. The quantities a and b are easily and rapidly determined by the spectroscope. P. Schoop has adapted Krüss's apparatus for quantitative spectral analysis for practical purposes. The instrument consists of a tube with slit, prism and telescope, which is so arranged that any position in the spectrum can be examined and determined.

The slit is divided in two halves, the upper is movable, the lower is fixed. Immediately in front of the lower slit is placed a vessel with parallel glass sides, 1 cm. apart, to hold the solution of dye stuff to be tested. By regulating the height of the solution in this vessel, two spectra are obtained, one of the source of light (a petroleum lamp) and the other the absorption spectrum of the solution. The darkest part of the latter is then found, and the movable slit regulated until the amount of light in each spectrum is equal. The extent of movement is shown on a drum attached to the micrometer screw, and serves as measure for the intensity of the light, that of the upper slit being the unit. The average of a number of readings, which can be made comfortably within a minute, is put down as the intensity of light.

Having in this manner determined the intensity of light, for a normal solution of a dye stuff, a similar determination at the same position of the spectrum suffices to calculate at once the concentration of a solution to be tested with the aid of the above formula.

Dilution causes no change in the position of the maximal absorption, and the spectrum of a mixture of two color solutions is equal to the sum of the absorption spectra of the single solutions.

The apparatus can also be used to analyze commercial mixtures of two and more colors; also to determine the end of the reaction in the formation of coloring matter (rosaniline by arsenic acid, or nitro-benzol, methyl violet, bluemelts, etc.), also for standardizing colored salt solutions for analytical purposes (permanganate) and for color reactions. O. L.

A VOLTAIC CELL WITH CARBON ELEMENTS AND WITHOUT METAL. By D. Tommasi and Radiguet (*Bul. Soc. Chim.*, **47,** 85).—The positive electrode of this cell is a carbon rod, coated with lead peroxide and enclosed in a canvas cover. This is placed inside a carbon tube pierced with holes, and the whole is surrounded by fragments of gas carbon in a glass jar, which is then half filled with a saturated solution of common salt. The cell gives an electro-motive force between 0·6 and 0·7 volt. It quickly becomes polarized, and is only adapted where an intermittent current is required; its duration is then practically unlimited, and there is no action when the circuit is not closed. The water must be replaced as it evaporates; a small quantity of calcium chloride added to the salt solution will prevent its evaporation. The theory of this couple is as follows: The conversion of one molecule of lead monoxide into the peroxide disengages 12·14 calories; the heat of formation of the monoxide being 51· calories, that of the dioxide must be 63·14 calories. The carbon decomposes water in closed circuit, the reaction being $C + 2\,H^2\,O = CO^2 + 4\,H$, and the thermal effects of this reaction are $102{\cdot}6 - 138 = -35{\cdot}4$ calories. In the canvas sack there is reduction of peroxide and formation of water, according to the equation, $Pb\,O^2 + 4\,H = Pb + 2\,H^2\,O$, the thermal reaction being $138 - 63{\cdot}14 = 74{\cdot}86$ calories. The resultant heat of the two reactions is the algebraic sum of their thermal effects, or $74{\cdot}86 - 35{\cdot}4 = 39{\cdot}46$ calories. If the volt be considered equivalent to 46·3 calories, the electro-motive force of the cell should be $\frac{39{\cdot}46}{46{\cdot}3} = 0{\cdot}85$ volt. With 47·16 calories as the equivalent of the volt, the electro-motive force should be $\frac{39{\cdot}46}{47{\cdot}16} = 0{\cdot}84$ volt. Direct measurements gave between ·6 and ·7 volt, and the difference is to be attributed to the facility with which the cell becomes polarized, and the possible formation of carbon monoxide which would diminish the heat disengaged by the first reaction. W. H. G.

PREPARATION, PROPERTIES AND CONSTITUTION OF INOSITE. By M. Maquenne (*Bul. Soc. Chim.*, **47,** 290; *Comptes Rendus*, **104,** 225).—Inosite has long been regarded as analogous to the glucoses in constitution, and although it has been extracted in small quantity from muscular tissue and from many plants, it had never been obtained in sufficient quantity to permit

of exact investigation. The author has succeeded in obtaining a considerable proportion of it from dried walnut leaves, which yield very nearly three grammes per kilogramme. For the method of extraction, we must refer to the original memoir. The composition of the crystallized substance is $C^6H^{12}O^6$ with two molecules of water, which are lost at 110°. Its chemical properties—the action of reducing and oxidizing agents assign to it the structure $C^6H^6(OH)^6$, and show it to be hexoxyhexhydrobenzene. W. H. G.

FORMATION OF HYDROGEN SILICIDE AS A CLASS EXPERIMENT. By A. Mermet (*Bul. Soc. Chim.*, **47**, 306).—The preparation of pure hydrogen silicide as a class experiment is tedious and difficult. Its spontaneous combustibility may be quickly and easily shown as follows: A piece of magnesium ribbon 2 or 3 centimetres long is introduced into a clean, dry, glass tube, 4 or 5 millimetres in diameter and 5 or 6 centimetres long and closed at one end. It is then heated in the Bunsen flame until a bright incandescence shows that a portion of the silica of the glass has been reduced by the magnesium; the magnesium silicide formed covers the bottom of the tube with a black deposit. Before the tube has become entirely cold, a few drops of hydrochloric acid are introduced. Instantly there is a disengagement of hydrogen mixed with hydrogen silicide, and the bubbles take fire at the mouth of the tube, producing a crackling sound and a white smoke of silica. W. H. G.

HOPEINE. (This JOURNAL, **123**, 419).—The hopeine claimed to have been discovered in wild hops by Williamson, has been shown by Ladenburg (*Berl. Ber.*, **19**, 783,) to be a mixture of morphine with another more soluble base. B. H. Paul (*Pharm. Jour.*, **111**, 877), and C. Lenken (*Chem. Zeitung*, **10**, 553,) have found that the other base is in all probability cocaine. W. H. G.

MELTING POINT OF MAGNESIUM. Victor Meyer (*Berl. Ber.*, **20**, 497).—The text books give (about) 500° as the melting point of magnesium, a temperature which does not agree with the observations of several manufacturers who pointed out the fact to the author. Experiments have shown that when heated in an atmosphere of hydrogen, magnesium melts almost simultaneously with sodium hydroxide, of which the fusing point is 800°. That of magnesium is very little below the latter temperature. W. H. G.

ON THE DESSICATION OF GASES.—J. D. van der Plaats (*Rec. Trav. Chim.* **6**, 45,) has published a review of the literature on the dessicating agents employed for gases, and concludes that sulphuric acid diluted with six or eight per cent. of water is preferable in all cases in which neither absorption nor combination takes place. Special attention is directed to the importance of repeatedly calcining with sulphuric acid the pumice used for gaining absorbing surface in order to decompose chlorides and fluorides, and washing between the calcinations with dilute sulphuric acid. The U-tubes employed should be drawn out and bent for connections after the pumice and acid have been introduced, or if a cork be employed it should be on the side by which the gas is introduced, and should be covered with good sealing wax. Caoutchouc tubes used for connections should be dried in the dark over sulphuric acid, and should be thick like those used for filter pumps, in

order to prevent passage of air and water vapor. Absorption tubes should always be weighed open after they have taken the temperature of the balance.

W. H. G.

SILVER IN THE VOLCANIC ASH FROM ERUPTION OF COTOPAXI, ON JULY 22 AND 23, 1885. J. W. Mallet (*Proc. Royal Soc.*, **42**, January 6, 1887).—The author has analyzed the ash collected at Bahia de Caraguez, about 120 miles due west from Cotopaxi, where it fell to the depth of several inches. The specimen was a light brownish-gray, very finely divided, mobile powder, soft to the touch. Quartz, two felspars, augite, magnetite and thin scales of deep-red specular iron ore were distinguished by aid of the microscope. When strongly heated, it turned dark red-brown, and fused to a nearly black slag. "Several concordant experiments proved that silver was present to the extent of about one part in 83,600 of the ash, or about two-fifths of a Troy ounce per ton of 2,240 pounds. Small as is this proportion, it must represent a very large quantity of silver ejected during the eruption, in view of the vast masses of volcanic ash which must have been spread over such an area as is indicated by the fall at so distant a point as Bahia de Caraguez."

W. H. G.

IN A PAPER read before the Photographic Society of Great Britain, Capt. Abney describes a method of determining the density of different portions of a negative, which consists, in brief, in throwing a magnified image of the negative upon a screen, in front of which is a rod which casts a shadow upon it. Any part of the negative can be moved into this part of the field, and at the same time a beam of light, from that employed for projection, is thrown by means of a mirror placed at one side, at a suitable angle, over the patch of light formed on the screen by the lens, throwing another shadow of the rod. The variation of the light from the second source is accomplished by passing it through sectors revolved by a small electro-motor, the aperture of the sectors being capable of measured variation, by which intensities are compared. By rendering the shadow of the rod equal in intensity and reading off the variation in the second source of light, as indicated by the width of sectors employed, the relative densities of the different portions of the negative can be determined as the relative values of the projecting light and comparison light are constant.

C. F. H.

AS A MOUNTANT for albumen prints without cockling, upon any kind of paper, Prof. Rood recommends a thick solution of bleached shellac in alcohol as meeting every requirement.

C. F. H.

THE ANALYSIS OF COFFEE. L. Pade (*Bul. Soc. Chim.*, **47**, 501).—The Municipal Laboratory of Paris has been engaged in examining the fraudulent manipulation of coffees, the fraud consisting in the manipulation of the green berries, and the moistening of the dried. The densities of the specimens were determined by the aid of a simplified Regnault's volumometer. The extreme densities of unmanipulated and sound specimens:

	Green Coffee.	*Roasted Coffee.*
Maximum,	1,368	635
Minimum,	1,041	505

The densities of green coffees manipulated by partial drying are between the lowest of the green and the highest of the roasted. This manipulation, which is carried on extensively in England and in Holland, is practised as follows: The too-advanced berries are separated from the damaged coffee; the remainder is carefully washed in order to remove the soluble salts derived from the sea water, and then bleached with lime water; it is again washed to remove the lime, and quickly dried in an oven through which passes a current of air. The desired tint is then given by a slight heating, or by dyeing with an orange dye; the latter colors are easily detected by macerating the coffee for a few minutes in alcohol, which dissolves the dye. Green Brazilian coffees are in a similar manner transformed into orange Javas, the profit being about thirty per cent. The densities of coffee treated in this manner in the laboratory were between 899 and 929, and a coffee purchased in the market and found to be colored with β naphthol orange had a density of 939. There is reason to suspect manipulation by partial roasting, when the density of a coffee is below 1,000.

During drying by heat, coffees lose from seventeen to nineteen per cent. of their weight, according to their kind and age. To compensate this loss, the dealers often endeavor to replace the water, but this is only practicable by the condensation of steam in the mass. Twenty per cent. of water may thus be added without the coffee appearing moist, but instead of being hard and crisp between the teeth, the berries are tough and elastic.

Coffee which has been roasted and then moistened loses part of its water on exposure to the air, and to prevent the loss, the grains are often coated with glycerine, palm oil, or even vaseline. The densities of such coffees are higher than those of normal roasted specimens—between 650 and 770. If, however, the roasting has been carried too far, the density may fall to 480, and a normal density may result from moistening.

The quantity of water that has been added to a coffee may be found very exactly by heating to 110° for six hours. Under such circumstances, dried coffees lose only one or two per cent., but such as have been moistened lose in addition the water that has been added. W. H. G.

THE TRANSFORMATIONS EFFECTED IN POTABLE WATER BY THE DEVELOPMENT OF BACTERIA. T. Leone (*Gaz. Chim. Ital.*, **16**, 505).—The author has studied the variations in the quantities of ammonia, nitrates and nitrites, occurring during twenty-two days in the water of Mangfall, in Monaco. His conclusions are that when the development of micro-organisms is considered in all its phases, their action is beneficial and purifying. The double function of oxidizing and reducing with which some bacteria seems to be endowed, is only apparent. Their unique function is to oxidize organic matter and the products of its decomposition. The oxygen, however, is furnished to the oxidizable matters by those substances which will yield it readily, and it is then the nitrates which contribute their portion. The oxygen of the atmosphere is the main agent in the oxidation of ammonia to nitrous and nitric acids, and when the medium in which the bacteria live is inaccessible to the air, the nitrification is retarded. The variations in the quantity of organic matter, and the

extreme variations in the quantities of ammonia, nitrous and nitric acids occasioned by bacteria, is of importance to the hygienist. The fact that in twenty-two days two-thirds of the organic matter was no longer revealed by potassium permanganate, and that the qualities of ammonia, nitrous and nitric acids, varied between zero and a relatively large gravity, shows that estimations of these substances are of value only when made on a water at the time it is delivered for consumption. W. H. G.

MISCELLANEOUS.

APPRENTICESHIP AND PROFESSIONAL TEACHING.—Printing is among the industries which have the greatest need of being raised and sustained in the quality of labor. What was formerly an art practised by a small number of select workmen, has now become a trade transformed by the requirements of quick production. The multiplication of daily papers, magazines and all classes of printed matter has resulted in a sensible lowering of the standard of workman's skill. Efforts should be redoubled, not only that the artistic production of printing may not be endangered, but that the common, cheap production may not fall below that degree of correctness which every industrial product should maintain. Apprenticeship, as it is now regulated, does not give satisfactory results, sometimes the master fails to do his duty, sometimes the apprentice breaks his engagement as soon as a first degree of education insures his gaining a salary elsewhere. Often it is impossible in one work-shop to train a workman in different branches of the same work, and often the workmen themselves limit the number of apprentices, fearing the influence of their labor on the rate of wages. The French government has tried to remedy this evil by establishing special schools for industrial instruction; still, many capitalists prefer to prepare, under their own direction, recruits for their force of workmen. This plan has been successfully carried out in M. Chaix's professional school for young printers in connection with the central railroad printing-house in France. Applicants must be thirteen years of age, and prove that they have received primary instruction. The term of apprenticeship is four years. Beside practical instruction directed by a foreman for each of the specialties, the apprentice receives ample instruction in history, geography, the ancient and modern languages. Knowledge necessary for him when he may be called upon to work from difficult and incorrect copy containing technical terms or quotations from foreign languages. Outside of the regular courses, there are lectures, distributions of books written for apprentices' use, a library of appropriate works, and many helps also for moral education. Hygienic conditions are assured by frequent medical visits, by a system of warm baths, and even by vacation trips to the mountains or the sea for those in poor health. Especial precautions are taken to prevent risks in the use of machines. The apprentices are taught foresight and saving, and start bank accounts with the percentage which they receive on the result of their labor. By training in dexterity, easy reading of manuscript, judicious use of characters and the intelligent disposition of tables of figures, they are led progressively to do productive work for which they may receive a bounty of from ten to seventy cents a day. After

finishing their course they easily earn from $1 to $1.20 a day.—*Bull. de la Soc. d' Encour., July, 1886.* C.

GRAPHICAL INTERPOLATOR.—In the *Annali della Società degli Ingegneri e degli Architetti Italiani*, Roma, Anno **1,** 1886, fasc. iv, a very ingenious device is proposed and described by G. Torricelli, C. E., to divide the distances between level curves or soundings, on charts, in any number of equal parts,

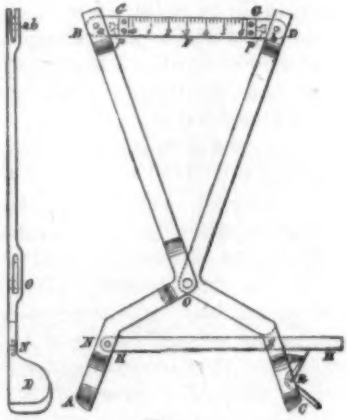
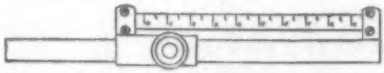


FIG. 1.

for the interpolation of other level curves or soundings, without using dividers or scale. The mean feature of such device is a rubber-band graduated scale, which can be stretched to more than double its ordinary length. This stretching the inventor accomplishes by securing the extremities of the rubber

Fig. 2.



scale to a pair of double tongs provided with ratchet, as shown in *Fig. 1*; but the simplest way of accomplishing this, we think, would be to secure such scale to a slide provided with a set screw, as shown in *Fig. 2*, which evidently would give the instrument a more compact and convenient form.

L. D'A.

THE OATMAN NIGHT-SIGNAL LANTERN.—A successful test of the Oatman night-signal lantern was made recently by officers of the army and navy. The common torch, lighted with lard oil or turpentine, has heretofore been used for carrying messages at night between far-off stations, on board ship as well as on shore, but the system has proved untrustworthy. The Oatman lantern is so arranged by a simple mechanical device that flashes of light can be shown as desired. These flashes correspond with the dash and the dot in the electric telegraph system—a long flash corresponding with the dash.

and a short flash with the dot. The lantern is not more than 18 inches high, and 8 inches square. A small lamp with the flame in the focus of a parabolic reflector furnishes the light. Fans close before the flame, by means of which the flashes are regulated, according to the Morse system of telegraphy. The flame is rendered steady by means of a forced draught. The longest distance signalled has been between Fort Myer and Sugar Loaf Mountain, Va., about thirty-five miles; signals have been exchanged between the reservoir in Brooklyn and Sandy Hook, about twenty miles apart.

Signals have been exchanged also between Ensign H. A. Bispham, U. S. N., Fleet Signal Officer of the North Atlantic Station, from Litchfield Castle, Prospect Park, Brooklyn, and Mr. Oatman, on Jersey City Heights, and Lieut. John Adams, at Fort Hamilton.

The instrument was in splendid working order, and Mr. Bispham spoke in the highest terms of the great utility of the invention.—*N. Y. World.*

ELIZABETH THOMPSON SCIENCE FUND.—This fund, which has been established by Mrs. Elizabeth Thompson, of Stamford, Conn., "for the advancement and prosecution of scientific research in its broadest sense," now amounts to $25,000. As accumulated income is again available, the trustees desire to receive applications for appropriations in aid of scientific work. This endowment is not for the benefit of any one department of science, but it is the intention of the trustees to give the preference to those investigations *which cannot otherwise be provided for*, which have for their object the advancement of human knowledge or the benefit of mankind in general, rather than to researches directed to the solution of questions of merely local importance.

Applications for assistance from this fund should be accompanied by a full statement of the nature of the investigation, of the conditions under which it is to be prosecuted, and of the manner in which the appropriation asked for is to be expended. The application should be forwarded to the Secretary of the Board of Trustees, Dr. C. S. Minot, Harvard Medical School, Boston, Mass., U. S. A.

The following grants have been made:

(1.) $200, to the New England Meteorological Society for the investigation of cyclonic movements in New England.

(2.) $150, to Samuel Rideal, Esq., of University College, London, Eng., for investigations on the absorption of heat by odorous gases.

(3.) $75, to H. M. Howe, Esq., of Boston, Mass., for the investigation of fusible slags of copper and lead smelting.

(4.) $500, to Prof. J. Rosenthal, of Erlangen, Germany, for investigations on animal heat in health and disease.

(5.) $50, to Joseph Jastrow, Esq., of the Johns Hopkins University, Baltimore, Md., for investigations on the laws of psycho-physics.

(Signed)

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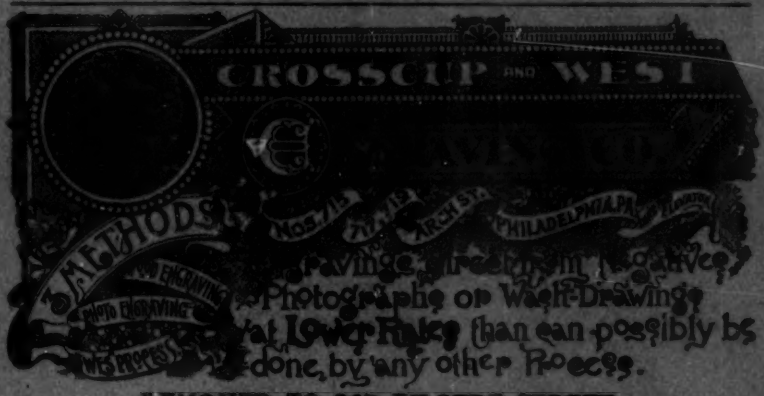

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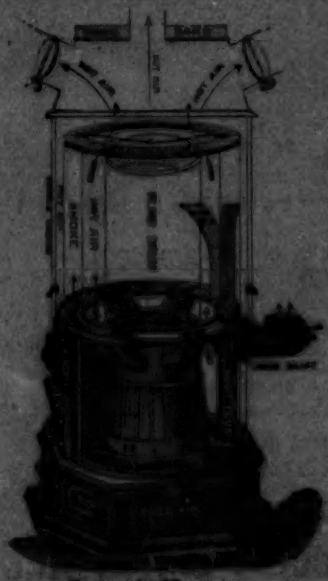

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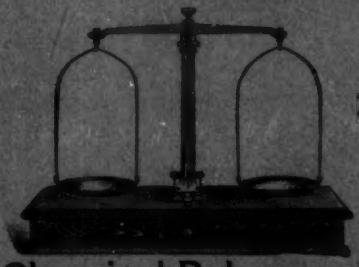

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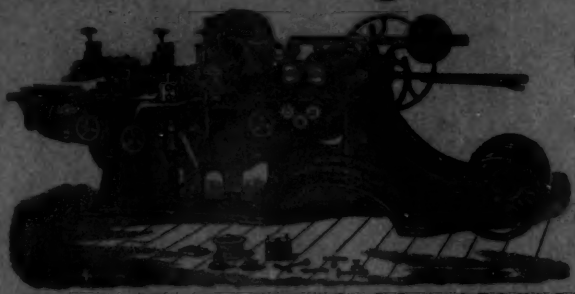

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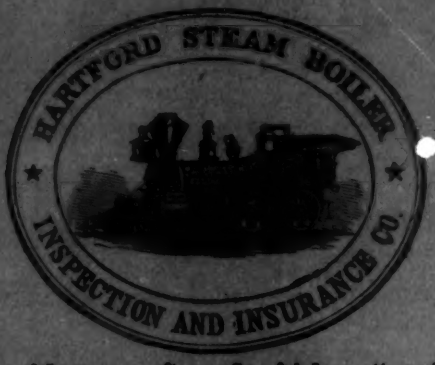

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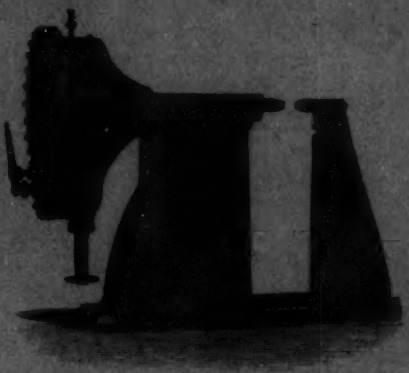

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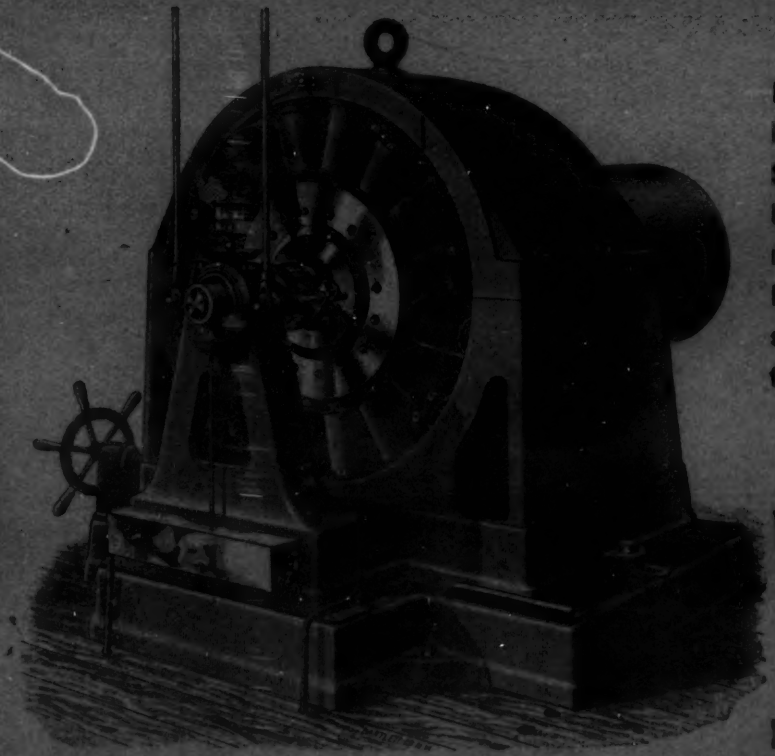

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CONTENTS.

The Stereoscope and its Applications. By Prof. Chas. F. Himes, Ph.D., ... 425
Tannin: Its Present and Future Sources. By Prof. Henry Trimble, ... 442
A New Process of Casting Iron and other Metals upon Lace, Embroideries, Fern Leaves and other Combustible Materials. By A. E. Outerbridge, Jr., ... 450
Note on the Modifications of the Bessemer Steel Process. By C. Hanford Henderson, . . 454
The Castner Sodium Process. By Mr. James Mactear, F.C.S., ... 463
On Ransome's Improvements in the Manufacture of Portland Cement. By R. J. Friswell, F.I.C., F.C.S., ... 470
The Julien System of Electrical Transmission. By Pedro G. Salom, ... 476
Book Notices, ... 484
Annual Report of the Director of the Drawing School of the FRANKLIN INSTITUTE, for the Sessions 1886-87, ... 484
FRANKLIN INSTITUTE, ... 487
Correspondence—Is Electricity Force or Matter? 488

SCIENTIFIC NOTES AND COMMENTS.

Astronomy and Physics.—The Observatory of Meudon (Janssen), 489. Recognition of American Astronomy (Glashier), 490. Photographic Search for a Minor Planet (Roberts); Solar Statistics and Terrestrial Magnetism (Wolf); New Double Stars (Hough); A New Unit for Absolute Time (Lippman), 491. Electrical Insulation, 492.

Chemistry.—Distillation and Purification of Mercury; Production of a Dye and Tanning Material from Catechu (Ziegler), 494. Determination of Phosphorus in Iron and Steel (Schneider), 495. General Methods for the Formation of Crystals by Diffusion (Guignet); Estimation of Aluminium in Presence of a Large Proportion of Iron (Thomson), 496. Spectroscopical Test of Tar Colors (Schoop), 497. A Voltaic Cell with Carbon Elements, and without Metal (Tommasi and Radiguet); Preparation, Properties and Constitution of Inosite (Maquenne), 498. Formation of Hydrogen Silicide as a Class Experiment (Mermet); Hopeine; Melting Point of Magnesium (Meyers); On the Dessication of Gases (Van der Plaats), 499. Silver in the Volcanic Ash from Eruption of Cotopaxi, on July 22 and 23, 1885 (Mallet); Method of Determining the Density of Negatives (Abney); Mountant for Albumen Prints (Rood); The Analysis of Coffee (Pade), 500. The Transformations Effected in Potable Water by the Development of Bacteria (Leone), 501.

Miscellaneous.—Apprenticeship and Professional Teaching, 502. Graphical Interpolator, (Tonicelli); The Oatman Night Signal Lantern, 503. Elizabeth Thompson Science Fund, 504.

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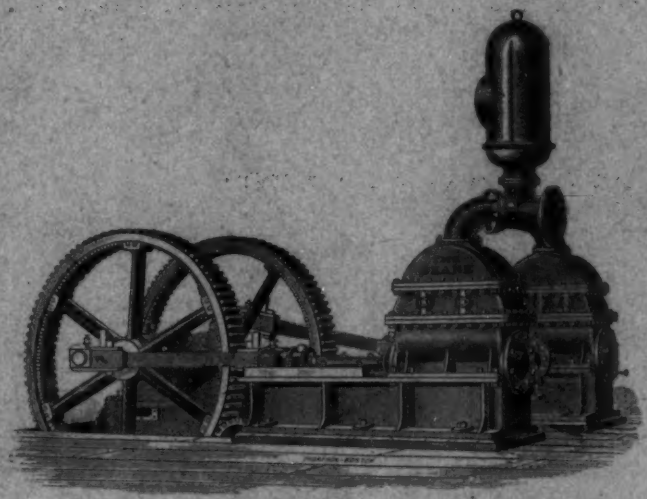

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